

University of Bahrain

College of Science



Applying Process Integration for Environmental Impact Assessment to Enhance Energy Conservation and Emissions Reduction

Thesis submitted in partial fulfilment of the requirements for the degree of
M.Sc. in Environment and Sustainable Development

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Kingdom of Bahrain
December 2016

جامعة البحرين

كلية العلوم



تطبيق تكامل العمليات لتقييم الأثر البيئي لتعزيز حفظ الطاقة وخفض الانبعاثات

أطروحة مقدمة كمتطلب جزئي لنيل درجة الماجستير في البيئة والتنمية المستدامة

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Defense committee's Approval

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M.Sc. Environment and Sustainable Development

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Abstract

Kingdom of Bahrain has formally adopted environmental impact assessment (EIA) process to address environmental aspects within development projects. Energy intensive projects such as those within oil and gas sector, petrochemicals, and power plants etc. have to go through EIA process before being approved.

The oil and gas sector is a significant consumer of energy and one of the largest emissions producers. Therefore, it is important to incorporate EIA process in the context of industrial project life cycle to ensure that environmental aspects are considered thoroughly. Furthermore, the role of EIA in energy conservation and emission reduction in the Kingdom Bahrain has not been investigated before. In addition, generation of alternatives is an area of improvement in EIA process in the Kingdom.

A framework that aligns implemented EIA process in the Kingdom of Bahrain with oil and gas project life cycle approach was formulated. The framework was formed by investigating implemented environmental regulations and procedures. The quality of selected EIA reports was investigated by performing a critical review against adopted evaluation criteria. A case study of oil processing unit was provided to demonstrate how process integration could be used as an enabling tool for EIA that aids the selection among alternatives based on energy efficiency and emission intensity. The case study compared between two alternative designs of atmospheric distillation unit by conducting energy analyses to determine the most energy efficient alternative.

The framework revealed a potential for thorough consideration of environmental aspects during projects life cycle within oil and gas sector. Evaluation of EIA reports showed better consideration of emission aspects over energy aspects. From the evaluation, it is recommended to enforce legislations to ensure efficient use of energy within industrial sector, adopt strategic environmental assessment (SEA) practice in the Kingdom of Bahrain and link it to energy planning, and encourage industrial firms to adopt energy management system to play the role of follow up to EIA mitigation measures. The application of process integration in the case study demonstrated that it is an effective tool in raising energy efficiency and minimizing expected emissions at early stage of chemical process design and facilitates the selection among alternatives.

Dedication

To my parents for their prayers

To my wife for her support

To my little son for the smile he draws on my face.

Acknowledgment

At the beginning of my second year in the program, I started thinking seriously about my research topic that can link between environment and my chemical engineering background. I did a search and found an article by Mohammed El-Halwagi et al. about EIA and process integration. I thought it will be a good topic to choose and will fit my interest. I discussed the idea with Dr. Humood Naser who was teaching us EIA course. He provided me with valuable advices that helped me in shaping the main idea of this research.

My grateful thanks are due to many people without whose helps this study would not have been carried out. Firstly, I would like to express my sincere gratitude to my thesis supervisor Prof. Elamin M. Elkanzi and the co-supervisor Dr. Humood Abdulla Naser for the continuous support, for their patience, motivation, and immense knowledge. Their guidance helped me in all the time of research and writing of this thesis.

EIA reports were major part of this research. These reports were provided by Bahrain Petroleum Company (Bapco) and Supreme Council of Environment. I would like to extend my gratitude to the Bapco HSE Manager Mr. Ahmed Khalil, Bapco Advisor Environmental Affairs Mr. Ijaz Ashraf and Supreme Council of Environment Environmental Specialist Hussain Abdulla for their cooperation in providing me with EIA reports and other valuable information.

My heartfelt appreciation is extended to my classmates who helped me in developing the idea of the cases study; Abbas Al-Hamaqi, S. Ahmed Jaafar and Nooh Isa.

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(4)	Industrial Projects Environmental Screening form (EA – 2)
(5)	EIA Reports Evaluation Sheets

List of Abbreviation

ADB	Asian Development Bank
ASTM	American Society for Testing and Materials
Bapco	Bahrain Petroleum company
CPDEP	Chevron Project Development and Execution Process
EA	Environmental Affairs
EC	European Commission
EIA	Environmental Impact Assessment
EIS	Environmental Impact Study
EMS	Environmental Management System
EnMS	Energy Management System
EPC	Environmental Protection Committee
GDP	Gross Domestic Product
HEN	Heat Exchanger Network
IAIA	International Association for Impact Assessment
ISO	International Standard Office
LLOC	Legislation and Legal Opinion Commission
NYSDEC	New York State Department of Environmental Conservation
PCPMREW	Public Commission for the Protection of Marine Resources, Environment and Wildlife
PI	Process Integration
PMI	Project Management Institute
SCE	Supreme Council for Environment
SEA	Strategic Environmental Assessment

Chapter One

Introduction to the Study

1.1 Introduction

Both population and development growth can be considered as notable feature for the Kingdom of Bahrain (PCPMREW, 2012a). Such growth put more pressure on the energy resources and contribute to the increase in the emission of greenhouse gases such as carbon dioxide (CO₂) (Abdelaziz et al., 2011). In Bahrain, the industrial sector has the largest share of the Kingdom's total energy consumption with around 59% (Enerdata, 2013). In addition, 89 % of the total CO₂ emission in Bahrain comes from both energy and industrial sectors (Alnaser et al., 2012).

Although Bahrain has worked to diversify its economy over the past decades, energy sector still has the major contribution to the national economy, where oil and gas account for 20% of gross domestic product (GDP) and provide about 80% of government income (Bahrain Economic Development Board, 2013). Given that oil is one of the main pillars to Bahrain's economy, Bahrain Petroleum Company (Bapco) has taken several initiatives to modernize the refinery aiming to enhance its competitive position, increase profitability, enhance energy efficiency and comply with all applicable local environmental regulations. Industrial projects can contribute positively to the national economy but can have the potential of adverse impact on environment.

Environmental Impact Assessment (EIA) is the process of identifying, predicting, evaluating and mitigating the biophysical, social and other relevant effects of development proposals prior to major decision being taken and commitments made (IAIA, 2015). EIA is one of the tools to achieve the balance between industrial development and sustaining the environmental conditions.

The Kingdom of Bahrain has set regulations and institutional arrangements that facilitate EIA practice. Regulatory framework for conducting the EIA in Bahrain is provided by both Legislative Decree No. 21 of 1996 with respect to the Environment (Official Gazette, 1996) and Ministerial Order No. 1 of 1998 with Respect to Environmental Evaluation of Projects (Official Gazette, 1998) (see appendices 1 and 2). Supreme Council for Environment (SCE) was formed according to Legislative Decree No. 47 of 2012 and became the responsible authority for screening, scoping, reviewing and evaluation of EIA studies before proposed projects are given approval (Official Gazette, 2012).

Although EIA process is contributing positively to the overall environmental situation and promoting the principles of sustainable development in Bahrain, still there is potential to enhance effectiveness of EIA in decision-making process.

Alignment between EIA process and project life cycle can aid in considering environmental aspects in decision-making process (Brent and Petrick, 2007). Furthermore, investigating the environmental regulations and procedures can provide a clear picture of how environmental aspects are covered throughout the stages of project life cycle.

Reviewing EIA reports is an approach to investigate the practice and performance of EIA process. It provides information on the quality of EIA reports or insights into the performance of specific procedures or measures within the EIA process (Naser, 2015). This approach can be utilized to ensure adhering to environmental regulations and enhance EIA practice.

Abdelaziz et al. (2011) indicated that energy intensive industries can improve energy efficiency by three different approaches namely; energy management system, energy saving technologies , and governmental energy policies and regulations.

Process integration (PI) is a family of methodologies for combining several processes to reduce consumption of resources (materials and energy) or harmful emissions to the environment. PI can be classified as technological energy saving approach and implemented widely in chemical industries such as oil refineries (Klemes et al., 2011).

1.2 Research Problem

Oil and gas sector is a significant consumer of energy in Bahrain and one of the largest emission producers. EIA is an implemented process in Bahrain that is intended to achieve the balance between economic development projects and maintaining good condition of the environment. Therefore, it is important to incorporate EIA process in the context of industrial project life cycle to ensure that environmental aspects are considered thoroughly. Furthermore, the role of EIA in energy conservation and emission reduction in Bahrain has not been investigated before. In addition utilization of PI as an enabling tool for EIA toward energy saving and emissions reduction will be illustrated by a case study.

1.3 Research Questions

This research is conducted to find answers to the following questions; What is the current practice regarding the alignment between

environmental tools i.e. EIA and Environmental Management System (EMS) with project life cycle of oil and gas sector in Bahrain?. What is the role of EIA studies in energy saving and emission reduction?. How energy aspects can be enhanced in EIA studies?. How can PI be used as an enabling tool for EIA to enhance energy efficiency and minimize emissions in oil processing units?. Are energy alternatives being considered in EIA reports?.

1.4 Research Objectives

In consistence with the research questions, the objectives of this research are; first, to present the alignment between environmental tools with project life cycle for oil and gas sector in Bahrain in a framework. Second, evaluation of the role of practiced EIA in Bahrain toward energy saving and reduction of emission. Third, provide a case study of applying PI to oil processing unit to illustrate how it can contribute to energy efficiency and reduction of emissions and how it can be used for generating alternatives.

1.5 Research Significance

Investigating legislations and procedures to illustrate the alignment between environmental tools and industrial project life cycle can provide clear idea whether environmental aspects are considered throughout the life cycle of these projects or not. This is a fundamental step to attain an integration of sustainability and project management (Marcelino-Sádaba et al., 2015).

In addition, studies have been conducted to evaluate EIA practice in Bahrain (Naser et al., 2008, Naser, 2010, Naser, 2012, Naser, 2015). However, the assessment of the role of EIA studies in Bahrain toward energy conservation and emission reduction has not been investigated before. Therefore, this study highlights the shortcomings that should be bridged to improve EIA practice in Bahrain. The case study will demonstrate how PI can be utilized as enabling tool for EIA process to ensure energy conservation and emission reduction for oil processing units by generating and selection of alternatives. Overall, the study will contribute to the improvement of EIA practice in Bahrain, which is one of the tools to promote the goals of sustainable development.

1.6 Research Structure

Figure 1 presents the structure of the study.

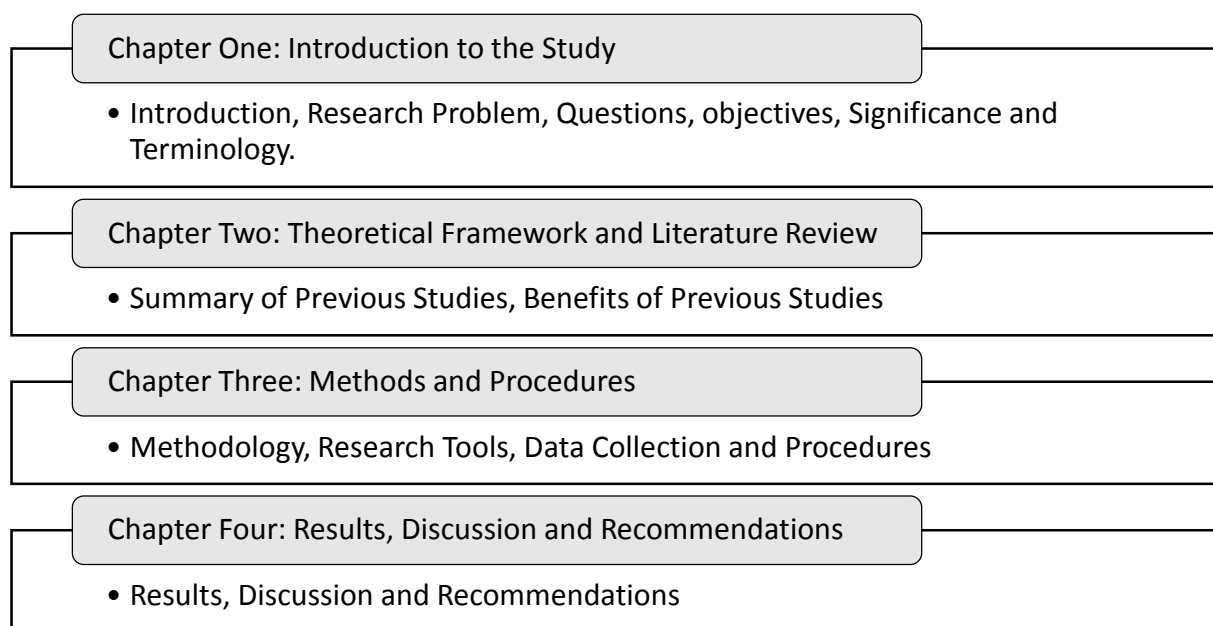


Figure (1)
Research's Structure

Conducted study is based on three main pillars as shown in Figure 2. There are vital connections between them. First pillar examines the legal contexts to ensure thorough consideration of environmental aspects within oil and gas projects and present it in conceptual framework. The second pillar evaluates the consideration of energy aspects within EIA reports. The third pillar provides a case study of how PI can be used as enabling tool for EIA process by generation and selection of alternatives.

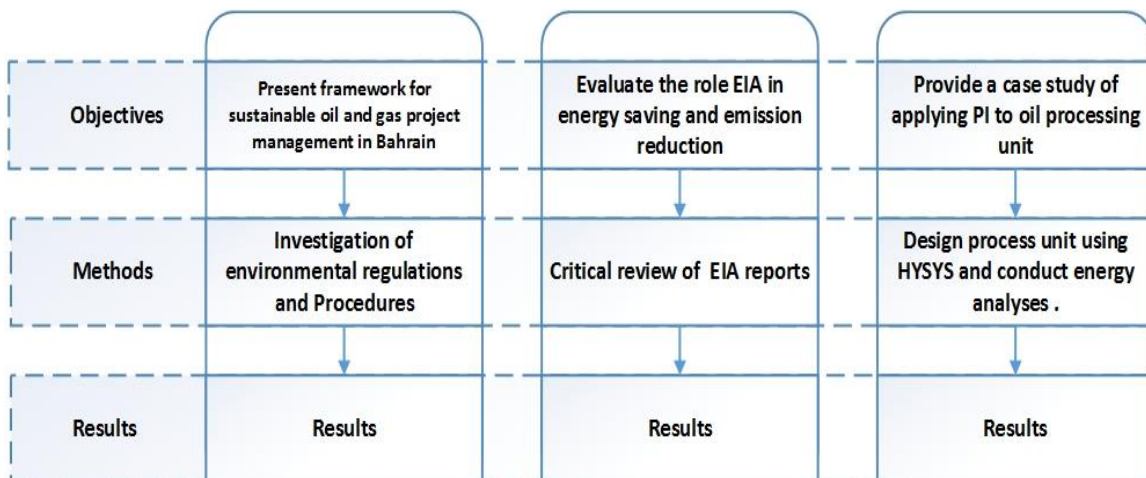


Figure (2)
Research's Pillars

1.7 The Study's Setting

Environmental regulations and standards are available on the website of the legal affair. In addition, environmental procedures for oil and gas projects were obtained from Bapco. These legal documents are going to be investigated to achieve the first objective of the research.

EIA reports for previous industrial projects were obtained officially from SCE and are going to be reviewed according to specific criteria in order to achieve the second objective of this study.

Aspen HYSYS® and Aspen Energy Analyzer®, which are commercial softwares for engineering design and simulation, are going to be utilized for the case study.

1.8 Research Terminology

Environmental Impact Assessment (EIA) is the process of identifying, predicting, evaluating and mitigating the biophysical, social and other relevant effects of development proposals prior to major decision being taken and commitments made (IAIA, 2015)

EIA Review is an integral part of EIA process and it is a formal procedure, which is undertaken by the competent authority to evaluate the quality of the EIA report to ensure compliance with legal and procedural requirements (Abaza et al., 2004)

Environmental Management System (EMS) is a management system that helps organizations to identify, manage, monitor and control their environmental issues in a holistic manner (ISO, 2015).

PI is a family of methodologies for combining several processes to reduce consumption of resources and/or reduce harmful emissions to the environment (Klemes et al., 2011).

Project life cycle is a collection of generally sequential and sometimes overlapping project phases whose name and number are determined by the

management and control needs of the organization or organizations involved in the project, the nature of the project itself, and its area of application (PMI, 2008).

Project Management refers to applying knowledge, skills, tools and techniques to project activities to meet the project requirements. In general project management is accomplished through five process groups namely Initiating, Planning, Executing, Monitoring and Controlling, and Closing (PMI, 2008).

Sustainable Development is ‘development that meets the needs of the present generations without compromising the ability of future generations to meet their own needs, integrating social, economic and environmental goals to mutually reinforce each other’ (Brundtland et al., 1987).

Chapter Two

Theoretical Framework and Literature Review

2.1 Sustainable Project Life Cycle Frameworks

The classical definition of sustainable development concept is the development that meets the needs of the present generations without compromising the ability of future generations to meet their own needs, integrating social, economic and environmental goals to mutually reinforce each other (Brundtland et al., 1987).

The attention to sustainability issues is rapidly increasing. In addition, many companies have adopted sustainability through their strategic direction and mission statement. However, the social and environmental dimensions of sustainability are rarely incorporated in programs and projects which are the tools of implementing the organization's strategy (Labuschagne and Brent, 2005).

Project can be defined as a temporary endeavor undertaken to create a unique product, service, or result. Hence, project management is applying knowledge, skills, tools and techniques to project activities to meet the project requirements (PMI, 2008).

The pressure is mounting for businesses to align operational processes with the objectives of sustainable development. That includes project management methodologies, which are a core business methodology of most companies. Thus, current project management frameworks need to be reviewed to ensure alignment with and incorporation of sustainability aspects as well as life cycle management principles. Nevertheless, the current theoretical frameworks do not efficiently take environmental issues into account (Labuschagne and Brent, 2005).

In order to address sustainable issues into project management a clear understanding of the different life cycles involved in a project and their

interactions is required. Labuschagne and Brent (2005) differentiated between three distinct types of life cycles involved in manufacturing sector which were; project life cycle, the process life cycle, and the product life cycle.

Various project life cycle approaches exist in the literature, the number of phases within each of these approaches differs as well as the names used to describe the phases. For example, in the chemical industry the typical plant life cycle consists out of six phases, namely: design phase, a construction phase, a commissioning phase, operation phase, and then decommissioning (Labuschagne and Brent, 2008).

In addition, product life cycles played an important role in the field of life cycle assessment. Life cycle assessment is defined as an analytical tool that evaluates environmental effects of a product, process or activity throughout its lifetime, from the extraction of resources up to the final disposal of the product (Marcelino-Sádaba et al., 2015).

It can be noted that due to the complex nature and diversity of project types, life cycle phases of project are different among industries, or even among companies within the same industry (Brent and Petrick, 2007). Projects within each sector has its unique characteristics, for instance the main characteristics of oil and gas industry are; huge investments, massive interfaces, complex engineering endeavors and high risks. The size and complexity of these projects require special attention to the project life cycle management. In addition, oil and gas industry are subjected to a variety of rules, laws, regulations, and standards. Environment is an important dimension to these regulatory instruments (Badiru and Osisanya, 2013).

Chevron is one of the major international oil companies and it is considered as a leading organization with vast experience and ability of operation and project management in oil and gas sector (Chevron, 2015). Since 1980s, Chevron has developed a unique project management process called Chevron Project Development and Execution Process (CPDEP). This process aimed to determine needed steps in order to move from the current state to the desired state in the future. CPDEP is widely implemented not only within Chevron but also applied by national oil and gas companies that have mutual agreement with Chevron. According to Gregory (2002) CPDEP consist of five main phases (see Figure 3) :

Identify and assess opportunities: at this stage, objectives of the project are clearly scoped, and opportunities are identified by conducting economic feasibility study to the proposed project.

Generate and select alternatives: at this stage, possible alternatives are listed and evaluation strategies for alternatives are established. Alternatives are generated using brainstorming, heuristics and evolutionary design techniques. Then analyzed to identify the value of each option, estimate the cost, schedule of work and quantify the associated risks. After that, preferred alternative is selected.

Develop preferred alternative: at the third phase scope should be defined fully and begin with detailed design. Also detailed execution plans should be developed.

Execute: by this phase, detailed design such shall be completed and consistently implement defined plans and finalize both business plan and operating plan.

Operate and evaluate: The final stage is to operate asset followed by monitoring and evaluate performance which can be done by benchmarking against objectives and competitors to identify new opportunities.

Bapco, the national oil and gas company in the Kingdom of Bahrain is responsible of all activities within this sector. According to its organizational structure major engineering projects department is accountable for project management activities conducted by the company. As per mutual technical services agreement between Bapco and Chevron, Bapco utilize the CPDEP for the management of its projects (Karim, 2014).

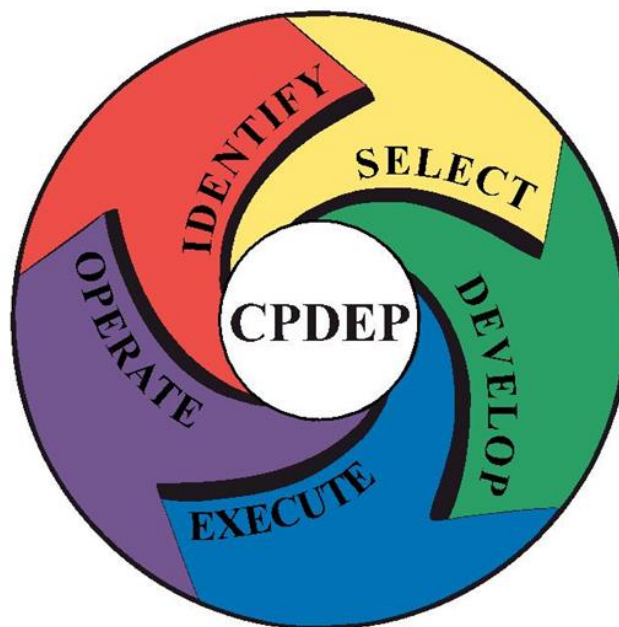


Figure (3)
Chevron Project Development and Execution Process

Oil and gas related activities pose several challenges to sustainability. Hence, EIA is broadly recognized as an important instrument to promote sustainable development in decision making (Lamorgese et al., 2015). EIA is the process of identifying, predicting, evaluating and mitigating the biophysical, social and other relevant effects of development proposals prior to major decision being taken and commitments made (IAIA, 2015). The following steps constitute a typical procedure for EIA adapted from (Pierre et al., 1999, EC, 2001, Noble, 2006) (see Figure 4):

Project preparation: The developer prepares the proposals for the project that give an overview of the nature and objectives of the proposed project. Main features of the project, site selection and a basic characterization of the effect of the process.

Screening: this step is conducted to determine whether an EIA is required for the project or not. Several approaches can be used for screening such as case-by-case, threshold-based and list-based screening.

Scoping: this should be conducted by competent authority to identify the primary matters and important issues to be included in the EIA. Moreover, the extent and boundaries of the assessment should be established at this stage.

Describe the baseline environment: in order to track any environmental impacts of the proposed project, description of condition of both present and likely future of the environment without the proposed project activity should be studied.

Generate alternatives: potential technologies and solutions for the project are generated and characterized prior to being examined to establish the preferred or most environmentally sound option.

Predicting environmental impact: conduct qualitative analysis to specify the consequences of planned activities on the environment.

Determining impact significance: describe quantitatively whenever possible, both positive and negative consequences in terms of magnitude, significance, reversibility, frequency of occurrence, period of occurrence, and nature of the impact.

Impact mitigation and management: to establish the measures that are necessary to avoid or minimize adverse impacts and to incorporate these measures into an environmental management plan or system.

Documentation of the environmental impact study (EIS): EIA process, discussions, the proposed measures for mitigation, the significance of effects and recommendations should be documented in an environmental impact statement.

EIS review: to determine whether the EIA report meets its terms of reference, provides a satisfactory assessment of the proposal and contains the information required for decision making. EIA report should be submitted to Environmental authority that is responsible of environmental licensing. In addition, contribution of interested civil societies and the effected general public in the review is significant. Based on the outcome of the review the decision on approval of the project can be made.

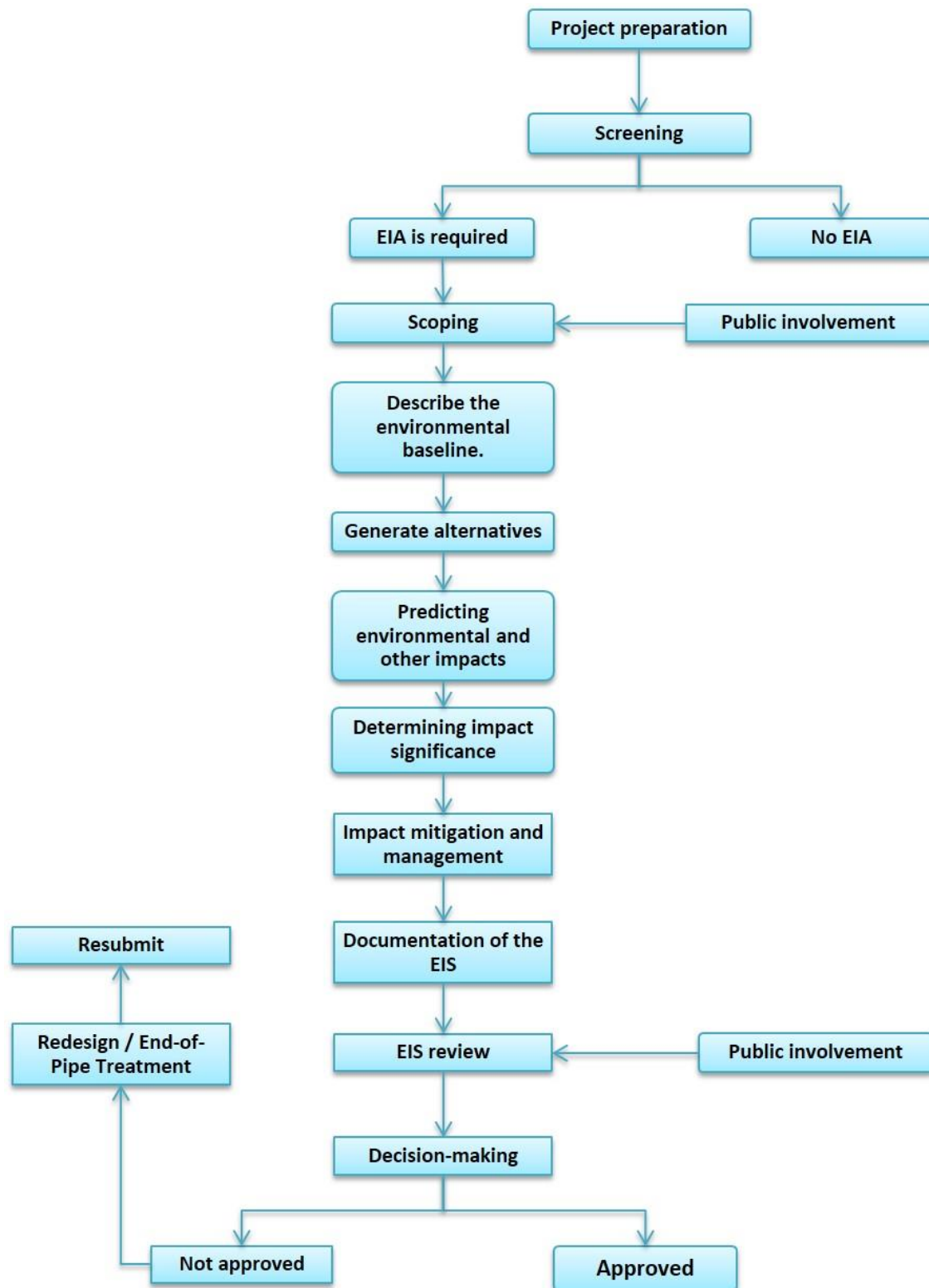


Figure (4)
Typical EIA Process adapted from (Pierre et al., 1999, EC, 2001, Noble, 2006)

Although EIA processes have similar steps as described previously, each country has its unique legal and institutional frameworks that arrange the practice of such process. Bahrain has several legal instruments related to environment such as those listed in Table 1. Regulatory framework for conducting the EIA in Bahrain is provided by both Legislative Decree No. 21 of 1996 with respect to the environment and Ministerial Order No. 1 of 1998 with respect to environmental evaluation for projects (Al-Kuwari and Ahmed, 2012).

Legislative Decree No. 21 of 1996 with respect to the environment defined EIA as “the study or studies being conducted before licensing a project to determine the possible environmental effects, the suitable procedures and measures to prevent or ease the negative effect, or increase the positive effect of the project on environment” (Official Gazette, 1996). EIA has become mandatory by law according to ministerial order No. 1 of 1998 with respect to Environmental Evaluation for Projects. The order explains the procedures of EIA and clarifies the responsibilities and duties of the concerned bodies in this process. According to this ministerial order, the project proponents is required to submit information and project details in order to determine the need of conduction the full EIA before being licensed. EIA study has to be conducted by an approved consulting firm according to ministerial order No.3 of 2000 with respect to the adoption of consulting firms operating in the field of environmental assessment for projects and environmental studies (Naser, 2012).

Table (1)
EIA Legislation in Bahrain (LLOC, 2015)

Some of EIA relevant legislations in Bahrain

Legislative Decree No. 21 of 1996 in Respect to the Environment (1996). (Appendix 1)

Ministerial Order No. 1 of 1998 with Respect to Environmental Evaluation of Projects. (Appendix 2)

Ministerial Order No 1 of 1999 with Respect to Control of Ozone Layer Depleting Substances.

Ministerial Order No. 10 of 1999 with Respect to Environmental Standards (Air and Water) and Its Subsequent Amendments. (Appendix 3)

Resolution of Minister of Housing, Municipalities and Environment No. 3 of 2000 on the adoption of consulting firms operating in the field of environmental assessment for projects and environmental studies.

Ministerial Order No. 8 of 2002 with Respect to Standards for Pollutants and Emissions from Vehicles and Inspection.

Resolution of the President of the Public Commission for The Protection of Marine Resources, Environment & Wildlife No. 3 of 2005 with Respect to Environmental Regulations and Standards in the Work Place.

Resolution of the President of the Public Commission for The Protection of Marine Resources, Environment & Wildlife No. 4 of 2006 with Respect to the Management of Hazardous Chemicals.

Resolution of the President of the Public Commission for The Protection of Marine Resources, Environment & Wildlife No. 3 of 2006 with Respect to the Management of Hazardous Materials.

Resolution of the President of the Public Commission for The Protection of Marine Resources, Environment & Wildlife No. 10 of 2006 with Respect to Source Emissions of Air Pollutants.

EIA process in Bahrain has been governed by several institutions since its ratification. Environmental protection committee (EPC) was established as per Decree No. 7 of 1980 with the aim of protecting the environment and managing natural resources. Later on the EPC was upgraded to Environmental Affairs (EA) according to the Legislative Decree No. 21 of 1996 under the Administration of Ministry of Housing, Municipalities and Environment. In 2000, the Environmental Affairs was re-organized under the Ministry of State for Municipalities and Environmental Affairs. In 2002, for integrating the efforts and resources to achieve an effective protection for the environment, the three main governmental bodies concerned with the environment were joined under the umbrella of the Public Commission for the Protection of Marine Resources, Environment and Wildlife (PCPMREW). The PCPMREW was established as per the Legislative Decree No. 50 of 2002 and was re-organized further by Legislative Decree No. 10 and No. 43 of 2005 (Al-Kuwari and Ahmed, 2012).

In 2012 the Supreme Council for Environment (SCE) was formed according to legislative Decree No. 47 of 2012. SCE replaced PCPMREW and became the responsible authority for environmentally licensing projects and developments. The Directorate of Environmental Assessment and Monitoring is responsible for screening, scoping, revision and evaluation of EIA studies before proposed projects are given approval (Official Gazette, 2012). Figure 5 illustrates EIA procedure in Bahrain.

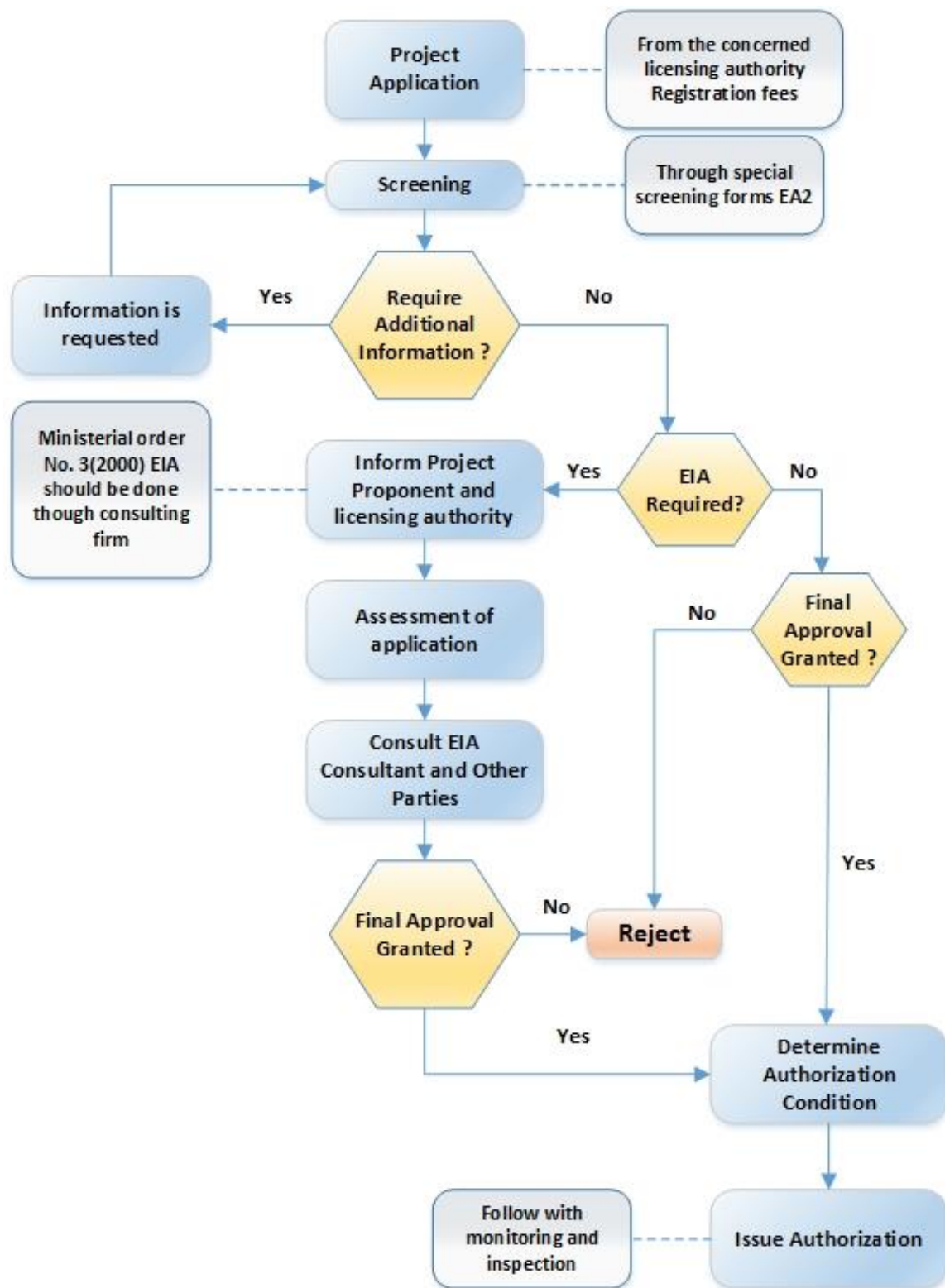


Figure (5)
Procedure of EIA in Bahrain (PCPMREW, 2012b)

Labuschagne and Brent (2005) emphasized on the need for aligning project management methodologies with the principles of sustainable development. A summary for several attempts to align between project life cycle and EIA process is going to be provided.

Brown and Hill (1995) stated that there is a need to transform EIA from being directed at the production of a standalone report to a process that facilitate decision making. To achieve such transformation, a framework of interaction between EIA with planning, design and approval of a project has to be established. In addition, Brown and Hill (1995) proposed the framework presented in Figure 6 and noted that a more comprehensive linkage model between EIA and project planning is required. Moreover, lack of practical guidance that bond between the activities of both project managers and EIA practitioners was noticed. To fill this gap, it was suggested enforcing the concept of decision-scoping. This concept integrates the EIA with earlier stages of project management. Such integration can be done by scheduling of all planning, design and execution activities and identifying needed environmental information relevant for each activity.

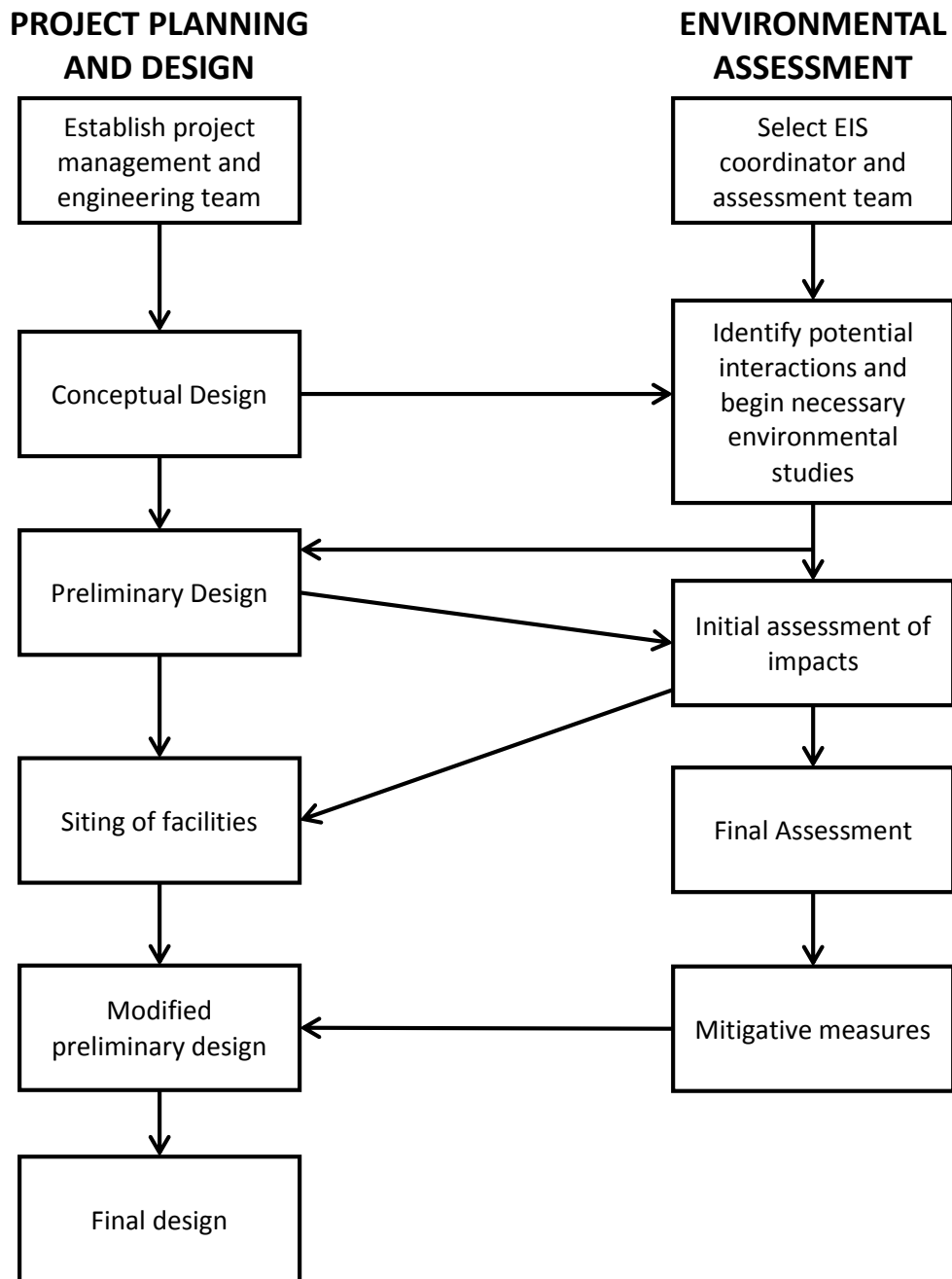


Figure (6)
Integration of Environmental Assessment into Project Planning and Design
(Brown and Hill, 1995)

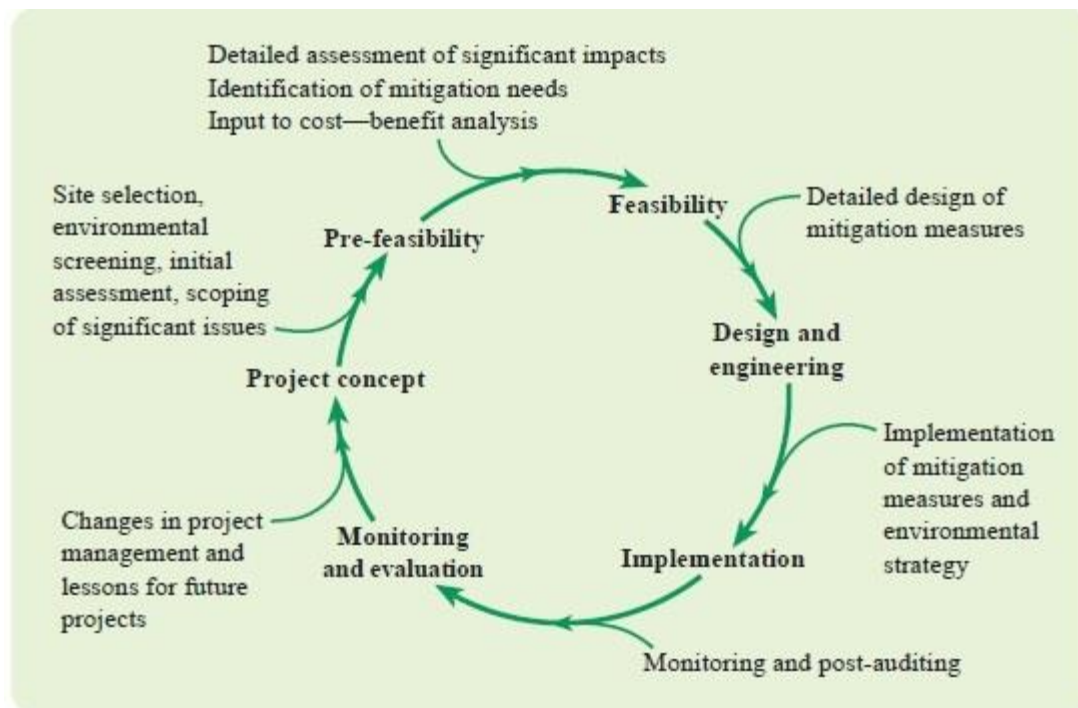


Figure (7)
ADB Model for the Alignment between EIA and Project Life Cycle

Asian Development Bank (ADB) has developed a model as shown in Figure 7 that explains how the EIA should be aligned with project life cycle. This model utilized a generalized project cycle of six main stages namely: 1) project concept; 2) prefeasibility; 3) feasibility; 4) design and engineering; 5) implementation; and 6) monitoring and evaluation. EIA has a role to play at each stage in the cycle. Most EIA activities take place during the prefeasibility and feasibility stages. Early in the project cycle, the EIA process involves site selection, screening, initial assessment, and scoping of significant issues. Next a project's feasibility study should include a detailed assessment of significant impacts, including gathering of baseline information; the prediction and quantification of effects; and review of the EIA. After these initial steps, environmental protection measures are identified, environmental operating conditions are determined, and environmental management plans are established. At the last stage in the feasibility study, the monitoring needs are identified, and

the environmental monitoring program and the environmental management plan are formulated. The environmental management plan is put into effect during the implementation of a project. This plan must include mitigation measures to reduce the environmental impacts that are generated throughout implementation. Environmental monitoring must be designed to provide information on the activity's actual impacts, compliance with environmental operating conditions, and the effectiveness of environmental mitigation measures. The evaluation of monitoring results is necessary to ensure that environmental objectives are achieved and, if necessary, that project modifications or remedial measures are undertaken to address unforeseen impacts (Lohani et al., 1997).

Ridgway (1999) provided a broad overview of how both EIA and Environmental Management System (EMS) are used at each stage in the project life cycle as shown in Figure 8. These two environmental tools were outlined and project life cycle was divided in to four general phases namely; planning and design, construction, operation, and decommissioning. It was stated that EIA is utilized in the planning and design phase of the project and EMS aids environmental management during operation phase. In addition, it was suggested that there is a potential for interrelationship between EIA and EMS where the outcome of EIA study (mitigation measures) can provide an important input to the initial environmental review of EMS.

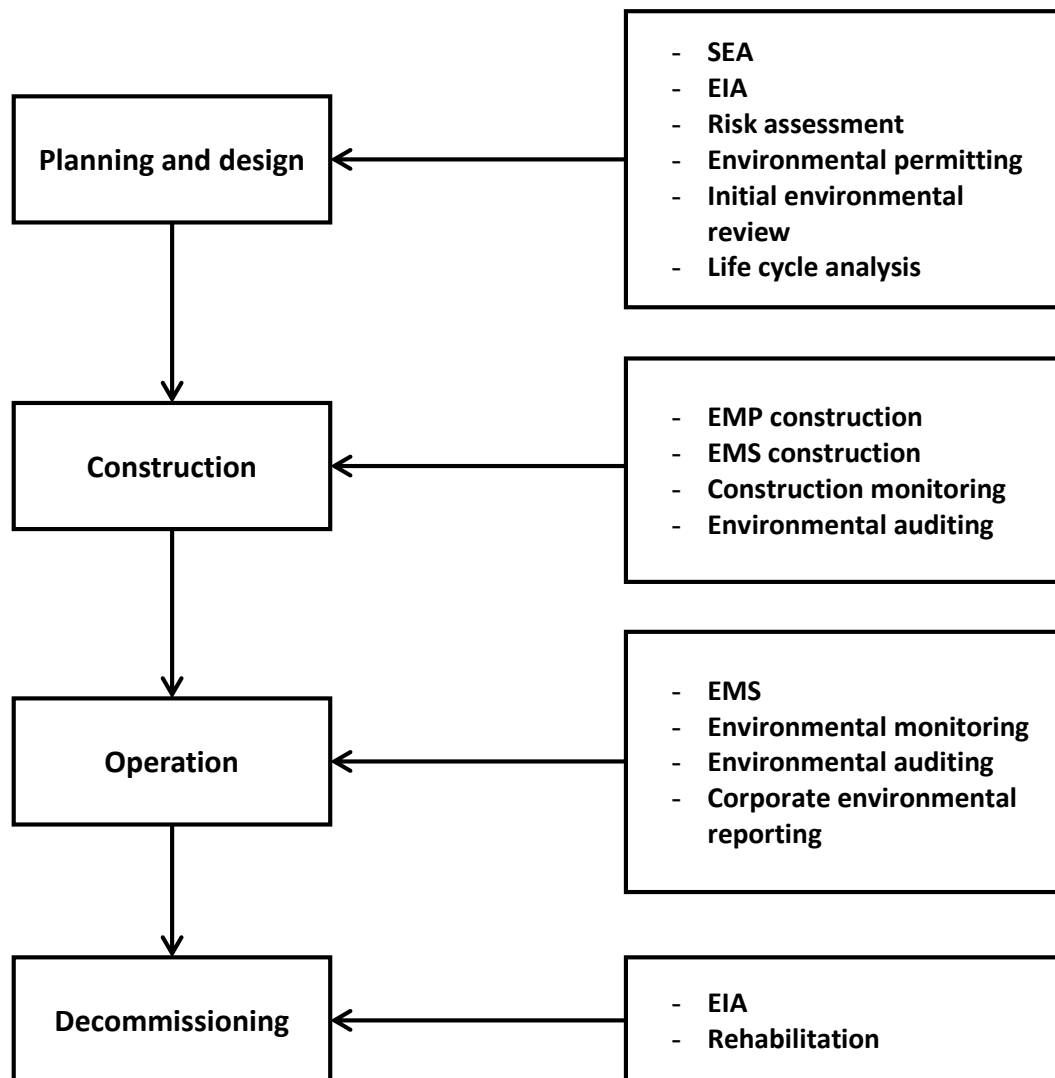


Figure (8)
The Project Cycle and the Use of Environmental Tools (Ridgway, 1999)

Brent and Petrick (2007) aimed to establish a model to inline the stages of an EIA to the project execution life cycle phases. The scope of work was for raw materials processing industry in South Africa. The research was dedicated to find answers to three main questions; what is the most appropriate interface model for the South African raw materials processing industry in the energy sector?, what is the most appropriate way to align the detailed steps of the South African EIA process with project life cycle?, and what model can be developed to ensure that specific

requirements are met for each specific gate in the project life cycle?. A questionnaire was compiled by Brent and Petrick (2007) then distributed to certain role players in EIAs. The results indicated that the South African legislated process is generally followed with problems in the execution of EIA relative to the project life cycle, such as late start of EIA. Based on the conducted survey an improved model is subsequently proposed to ensure the effective alignment of the EIA process with project management practices. Figure 9 summarized the proposed model.

Project lifecycle phase	Stage gate	EIA activities and deliverables
Pre-feasibility		Pre-application screening stage 1 to include: - Obtain relevant information regarding the proposed project. - Description of activity - Need and desirability - Site assessment - Consider alternatives from an environmental perspective - Preliminary identification of aspects and potential impacts on the environment - Screen the project in terms of whether an EIA is required or not. - Listed activity - Listed area - Impact on the environment
Feasibility	1	Screening decision: required to conduct an EIA or not (in other words, whether an application for authorisation needs to be submitted or not) (Applicable to projects that require an EIA) Pre-application Screening Stage 2 to include: - Identify aspects and potential impacts on the environment. - Determine at this stage which aspects may be applicable - Preliminary significance rating to determine whether aspects and potential impacts need to be assessed by specialists - Identify responsible persons to assess potential impacts - Start specialist baseline studies - Identify list of stakeholders/interested and affected parties (I&APs) to involve during the public participation process - Screen the project in terms of project category to determine which process need to be followed: Small/low impact projects Extended screening process (initial assessment) - Application for authorisation - Determine feasible alternative Large/high impact projects Full EIA process - Application for authorisation - Plan of study for EIA - Determine feasible alternative (can start with the scoping process and public participation process at this stage)
	2	- Register with potentially applicable aspects and impacts with responsibilities - Screening decision - Proof of application for authorisation submitted - Plan of study for EIA report and approval from the lead authority (for big/high impact projects) - Environmentally feasible alternatives report - List of I&APs to involve during public participation
Basic design		Extended screening process (initial assessment) - Initial assessment - Conduct public participation - Prepare preliminary environmental management plan (EMP) Full EIA process - Scoping process - Conduct public participation - Conduct impact assessment (specialist studies) - Prepare preliminary environmental management plan (EMP)
	3	Extended screening process (initial assessment) - Initial assessment report - Preliminary EMP - ROD Full EIA process - Scoping Report - Decision on Scoping Report from relevant authority - Specialist studies - Environmental impact report (EIR) - Prepare (EMP) - ROD
Detail design		Extended screening process (initial assessment) and full EIA process - Continue public participation - Prepare updated (detailed) EMP to be included into the contractor's contract and be used to develop EMS
Construction	4	Detail environmental management plan (EMP)
	5	Conduct audits against the EMP Audit reports
Start-up and hand-over		Conduct audits against the EMP
	6	Audit reports Conduct audits against the EMP
Operations and maintenance		
	7	Audit reports Conduct audits against the EMP
Closure		

Figure (9)
Proposed Model to Align the EIA Process with Project Life Cycles in the Energy Sector (Brent and Petrick, 2007)

Brown and Hill (1995) study paid an attention to the importance of the interaction between EIA and projects at early stages (i.e. planning and design). On the other hand, some statements about shortcoming in EIA were generalized without referring to statistics or induction studies. Furthermore, the implemented method to develop the suggested framework was not elaborated.

The approach provided by ADB model was generalized to be applicable for different types of projects whereas projects of each sector have its own characteristics and each country has its own set of environmental legal and institutional framework.

Ridgway (1999) illustrated of how EIA and EMS can be linked and aligned to each phase of project cycle. However, the provided approach was abroad and need to be tuned to suite specific type of industrial activity such as oil and gas sector.

Brent and Petrick (2007) were able to narrow the scope of the alignment to meet the specific requirements of raw materials processing industry in the energy sector and to put it within the context of specific legal and institution obligations of South Africa.

Reviewed literatures have common hypothesis which is alignment between environmental tools such as EIA and EMS with project cycle can contribute positively to the practice of EIA and promote the integrity of environment.

The present study share the same concern and one of its objectives is to present the current alignment of EIA process and management of project life cycle at oil and gas sector in Bahrain. Investigating the current practice of considering environmental tools (i.e. EIA and EMS) in project

management of oil and gas sector in Bahrain and illustrate that in conceptual framework is essential step analyze and evaluate implemented procedures. That will contribute to strengthen of EIA process and overcome the shortcomings.

2.2 The Role of EIA in Energy Conservation and Emissions Reduction

The following section of this chapter is going to focus on the literature review for the second pillar of the present study, which is reviewing of EIS to investigate the role of EIA in energy conservation and emission reduction. The EIS review is an integral part of EIA process and is intended to ensure that the report contains the information necessary for decision-making purposes. The common practice is to form a multidisciplinary review team to evaluate the quality of the report to confirm compliance with EIA legal and procedural requirements (Abaza et al., 2004).

Important information can be obtained by reviewing EIS such as investigating the practice and performance of EIA process. Furthermore, EIA reports' review can provide insights into the performance of specific procedures or measures within the EIA process (Naser, 2015).

Review of EIS quality has been discussed internationally. The most commonly used method is a review checklist or review package. Number of “review packages” are available, such as reviewing the quality of environmental statements by Lee et al. (1999), the guidance on environmental statement review by European Commission (EC, 2001), and the environmental statement review package by Oxford-Brookes Impact Assessment Unit (Glasson et al., 2005).

EIS review can be applied to evaluate the performance of EIA in managing the environmental impacts resulting from the specific industrial activity. Sandham et al. (2013) investigated the quality of environmental impact reports of explosives manufacturing projects in south Africa. The study employed the Lee et al. (1999) review package, with some modifications, to determine the quality of EIA reports of four case studies from explosives projects. The results revealed that the EIA studies were of a generally satisfactory but with some shortcomings that can be overcome by improved training, quality review, development of guidelines and the use of risk assessment.

Saif et al. (2015) stated that the quality of EIA reports has significant role in the effectiveness of EIA system. They conducted a study to review the quality of 100 EIA reports in Pakistan using comprehensive review checklist derived from several environmental review literatures. The study showed that the reports prepared for international funding agencies have better quality than those for local development projects.

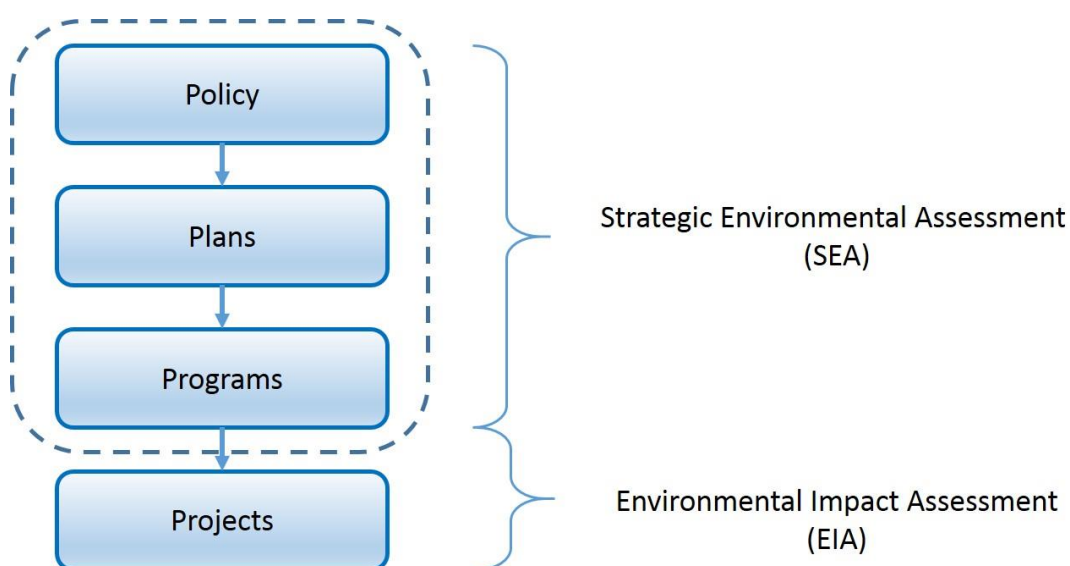


Figure (10)
Link between SEA, EIA and Planning Tools (Thompson et al., 2013)

As shown in Figure 10, EIA is provided for the level of individual projects, whereas significant environmental issues should be addressed at a higher level of planning. Moreover, Strategic Environmental Assessment (SEA) is powerful tool that can be apply for energy planning (De Montis, 2014). SEA has not yet been widely adopted in relation to energy sector. Though, recently SEA has been transposed into national law by all the member of European Commission (Jay, 2010).

De Montis (2014) stated that report quality review package is a powerful tool for investigating the comparative strengths and weaknesses of EIA practice. He studied the SEA of the energy planning tools (i.e. Regional Energy Plan, Provincial Energy Plan, and Municipal Energy Plan) in Italy. SEA report review package developed by Fischer (2010) was used to achieve the objective of the study. Nine SEA reports were subjected to the review and the results reveled that baseline description, and identification of key environmental issues can be interpreted as strengths. On the other hand, both consideration of reasonable alternatives and the impact of public participation on SEA efficiency were unsatisfactory.

Quality of EIA reports in Bahrain has been investigated however, these studies were mainly focused on overall quality of the system and the ecological aspects. These studies were explored and summarized as the following.

Evaluation of ecological assessment which is a fundamental part of environmental impact assessment has been conducted by Naser et al. (2008). The assessment covered the quality of ecological input in 15 Bahraini EIA reports concerning coastal and marine developments between 1996 and 2004. The quality of reports was rated according to Lee et al. (1999). The overall quality of selected reports was categorized as

either borderline quality, or poor quality. Main weaknesses were limited new ecological surveys, inadequate evaluation of impacts, neglecting cumulative and long-term impacts, and failing to address adequately mitigation and monitoring measures.

Overall EIA system in Bahrain has been evaluated by Naser (2012). Evaluation method was to examine legislative and administrative frameworks of EIA as well as aspects of EIA process against developed criteria. The study concluded that EIA is increasingly contributing to the overall environmental policy objectives and promoting the principles of sustainable development in Bahrain. On the other hand, there are challenges facing an effective EIA process in Bahrain such as late implementation where in most cases, project's sites were allocated or purchased before launching EIA. Therefore, implementation of EIA process at early stages of project life cycle is an essential step to promote the practice of EIA within the country.

Recently, Naser (2015) investigated the practice and effectiveness of EIA in protecting coastal and marine environments in Bahrain. Two methods were utilized to achieve this objective which were; reviewing selected EIA reports and surveying opinions of EIA experts, consultants, academics and other relevant bodies. Several environmental statement review packages; (Lee et al., 1999), (EC, 2001), and (Glasson et al., 2005) were explored and specific criteria to review EIA reports related to coastal and marine environments were formulated and modified to accommodate the environmental contexts in Bahrain. The quality of the reviewed EIA reports was rated based on the specific quality index. Twenty Bahraini EIA reports were obtained officially and reviewed accordingly.

Naser (2015) obtained opinions of EIA experts using survey questionnaire which was composed of three main parts about; effectiveness of EIA process in Bahrain, achievement of EIA goals in coastal and marine environments in Bahrain, and constraints that may restrict the effectiveness of EIA in Bahrain. The study identified constraints that restrict the effectiveness of EIA in protecting coastal and marine environments in Bahrain. In conclusion, enhancing the current practice of EIA process and adopting strategic environmental assessment is vital to maintain a sustainable use of coastal and marine natural resources in Bahrain.

While Naser et al. (2008) and Naser (2015) focused on ecological input in EIA reports, there is a need to investigate other aspects as well, to ensure achieving interdisciplinary principle in EIA practice (Pierre et al., 1999). For instance, energy consumption and its associated emissions are essential environmental aspect in Bahrain. There is no available literature about evaluating the quality of EIA report in terms of energy conservation and emission reduction in Bahrain and the provided study will be an initial step to fill this gap in this area.

Relationship between economic growth, energy consumption, and CO₂ emission is anticipated to be directly proportional. These relationships within the Gulf Cooperation Council (GCC) countries which are among the highest CO₂ emissions producers have been studied. The results showed that urbanization has the incremental impact on; CO₂ production, energy consumption, and economic growth Asif et al. (2015)

Both population and development growth can be considered as notable feature for the Kingdom of Bahrain. Furthermore, production of electricity between 2000 and 2011 rose from 5.5 to 12.3 TWh. The industrial sector has the largest share of the country's total final

consumption of energy, which account for 59% (Enerdata, 2013). Around 95% of CO₂ emission in Bahrain comes from; energy sector, oil production, and refinery (PCPMREW, 2012a).

The relationship between economic growth, energy consumption and CO₂ emissions from 1980 to 2007 in Bahrain was investigated by Jafari et al. (2015) using imperial method. The results revealed that the relationship between energy consumption and CO₂ emissions is directly proportional. Thus, reducing energy consumption is essential to reduce CO₂ emissions. Jafari et al. (2015) study proved that it is possible to reduce emissions without sacrificing economic growth. It was suggested that Bahrain can carry out energy conservation strategies and a carbon emissions reduction policy in the long run without impeding economic growth.

The method of evaluating the quality of EIA reports implemented by Naser (2015) is going to be utilized in this study to examine the role of EIA in Bahrain toward energy conservation and reduction of associated emissions. Details of evaluation method are going to be provided in chapter 3 of this study.

2.3 Process Integration as an Enabling Tool for EIA

The third pillar of present study is PI as an enabling tool for EIA. This section focused on how PI can serve EIA and facilitate the selection among alternatives. PI can be considered as a family of methodologies for combining several processes to reduce consumption of resources or harmful emissions to the environment. In addition, heat integration which is part of (PI) can be describes as an engineering method that aim to achieve

energy targets such as maximizing heat recovery and minimizing utility usage.

Friedler (2010) provided an extensive historical overview of all developments in the PI and the significant contribution of the PI, Modeling and Optimization for Energy Saving and Pollution Reduction (PRES) series of conferences. Friedler (2010) started from the very beginning of this research area and stated that Linnhoff and Flower (1978) developed a technology that is now considered as the foundation of heat integration. The PRES series of conferences have contributed to the development of PI methodologies and illustration of successful case studies is considerable.

Heating and cooling are common process operations in industries. To satisfy the need for heating and cooling, industrial operations require extensive use of different forms of energy. For instance, fossil fuels are widely used to generate heating media or to drive power generation cycles. The excessive usage of external heating utilities account for substantial economic weight in the form of operating costs, depletes unsustainable energy resources, and generates large quantities of greenhouse gas emissions. Consequently, considerable attention has been given to the problem of conserving energy through heat integration and the synthesis of heat-exchange networks. The basic idea for heat integration is that there are process streams and units that need to be heated and other process streams and units that need to be cooled. Before using external utilities to provide the necessary heating and cooling, heat integration seeks to transfer the heat from the process hot streams and units to the process cold streams and units. The remaining heating and cooling tasks are then fulfilled using the external heating and cooling utilities (El-Halwagi, 2012) (see Figure 11).

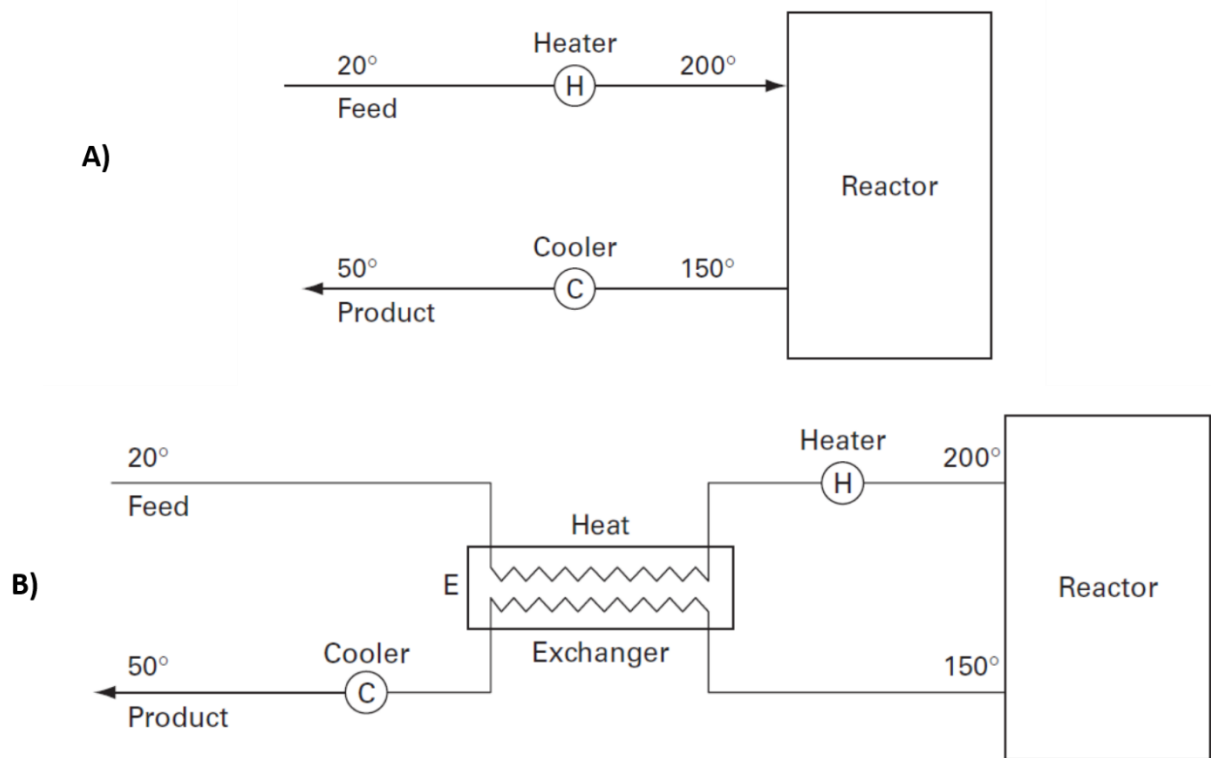


Figure (11)
A) Simple Process Flowsheet B) Simple Process Flowsheet with Heat Exchange
(Kemp, 2007)

PI approach can be utilized during process design, retrofitting and operation of chemical process. The following are the main key steps in PI summarized from El-Halwagi (2012):

Task Identification: First step is to express clearly the design in terms of actionable tasks. For example, operate at minimum external energy consumption.

Targeting: Identification of performance benchmarks before detailed design.

Generation of Alternatives: Use a framework that includes all configurations of interest and effectively identify those alternatives that meet the target at minimum economic and environmental cost.

Selection of Alternative(s): Selection of optimum solution from the possible alternatives. Several techniques can be used at this stage such as graphical, algebraic, and mathematical optimization techniques.

Analysis of Selected Alternative(s): Evaluation of generated alternatives based on various performance indicators using process analysis techniques (e.g., computer-aided simulation, safety analysis, etc.)

In a typical heat integration problem streams data should be extracted from the heat and mass balance or process flow diagram. This data can be input to construct and study the pinch diagram or composite curves to determine energy target. Composite curves, which are plots of temperature versus cumulative heat flow, are constructed for hot and cold streams. For a given pinch point, the minimum heating and cooling requirements can be read from the composite curves as shown in Figure 12.

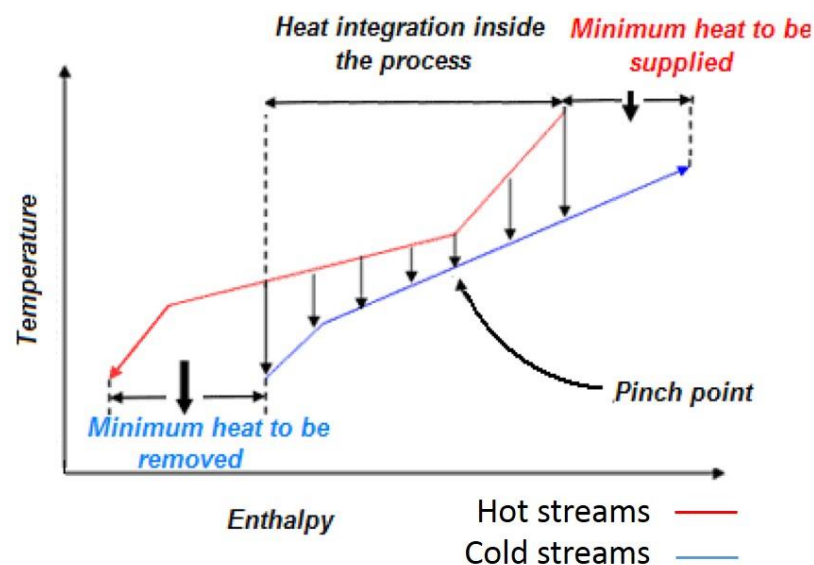


Figure (12)
Typical Composite Curve (Reverberi et al., 2011)

Before discussing the details of proposed case study, it is important to understand the linkage between the three main pillars of the present research. From the provided literature review it was clear that generating and selecting alternatives are common area between both second phase of CPDEP (i.e. generate and select alternatives) and fifth step of EIA process (i.e. generate alternatives).

El-Halwagi et al. (2009) discussed from process engineering prospective, the limitation of generating and selecting alternatives within EIA process. This limitation mainly is the large number of alternatives may need to be generated and analyzed. Therefore, PI is suggested to overcome this limitation. It can be employed as an effective framework for facilitating process engineering activities associated with the EIA, reducing engineering efforts, providing valuable insights, and systematizing the design effort while reconciling the various process objectives with the environmental objectives. PI can serve as an enabling tool for EIA and facilitate EIA in several ways such as; process synthesis to generate alternatives, set targets for environmental impact benchmarking prior to performing detailed design, and integration of alternatives with the rest of the process.

Oil refinery is one of the major energy intensive sectors, where large amount of energy is used to run process equipment and heat up feeds prior to the processing in operation units. Fossil fuel is the main source of energy for oil refineries, such type of energy produce massive amount of air pollutants. Oil processing is one of the areas that PI can be used to enhance the efficiency and contribute to reduction of emissions.

Figure 13 shows block flow diagram of a typical refinery. Crude distillation is the first and most important part of any refinery. The crude

atmospheric distillation units provides refined products such as gasoline, kerosene and diesel for direct sale and feedstock to the other process units in the refinery. In general, crude oil enters the refinery after some initial treatment to remove impurities and sediments. After that, oil is heated prior to being fed into the atmospheric distillation tower. The majority of the refineries send the heavy products of atmospheric distillation unit for further processing such as; vacuum distillation, catalytic cracking, hydrocracking, reforming, etc. (Chang et al., 2012)

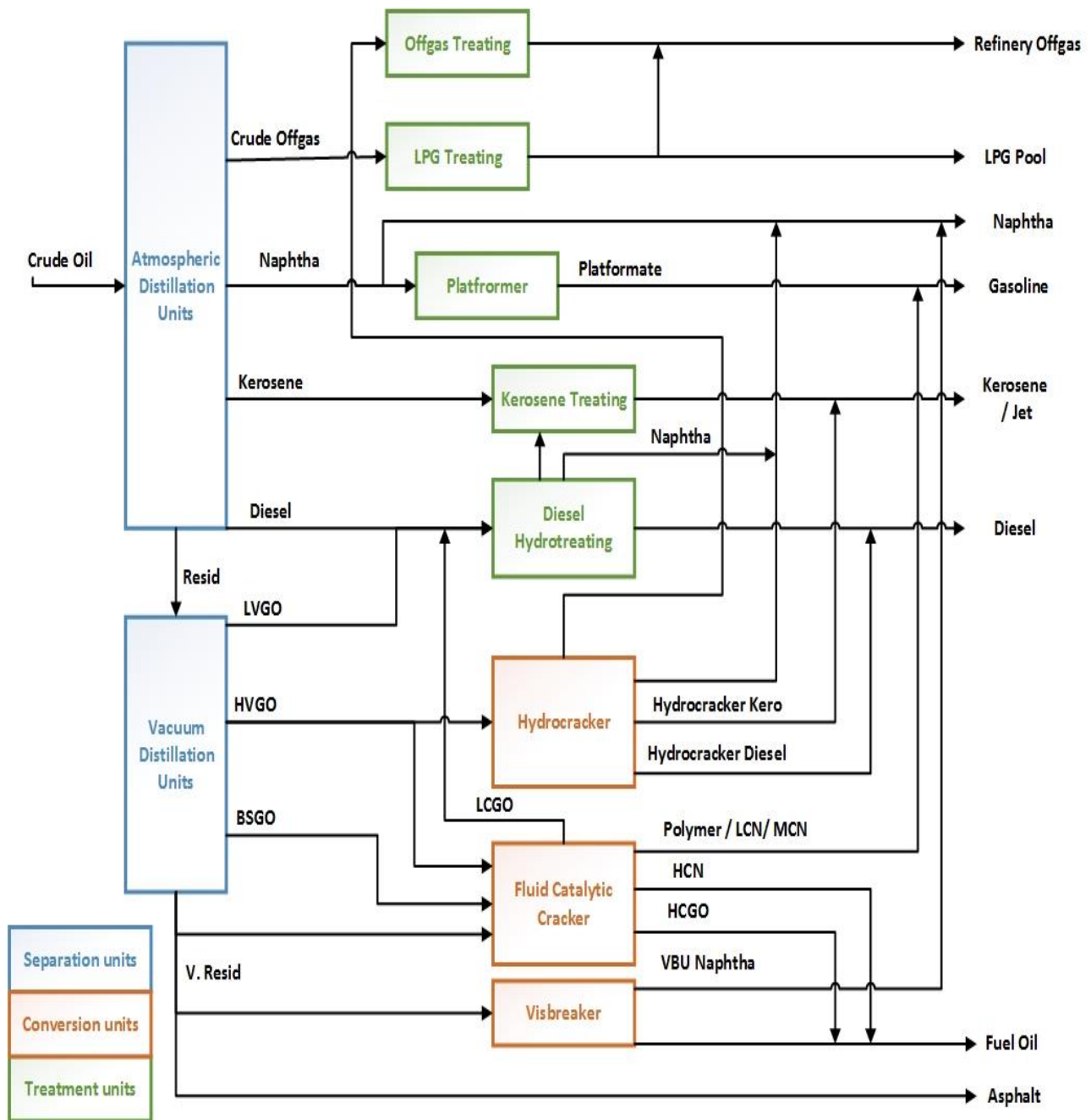


Figure (13)
Block Flow Diagram of a Typical Refinery

In a typical crude oil distillation unit (Figure 14), oil is fed from storage tanks or pipeline at ambient temperature. Then heated via heat exchangers network (preheat train). The preheat train consist of series of heat exchangers to raise the temperature of crude to around 280°C using hot product streams which reduces the overall energy consumption in the

refinery. Crude oil is heated further in furnace up to around 360°C, at this temperature crude oil will be converted from liquid phase to vapor-liquid mixture phase. The mixture is fed to the lower part of a distillation column. Distillation column consists of a main distillation tower with side-strippers. The column, which usually has 30 to 50 stages in order to separate the feed into products according to boiling points ranges. The overhead condenser condenses the stripping steam and any condensable hydrocarbons, some of this stream is returned to the column as reflux and some is withdrawn as the top product. Liquid side-streams are withdrawn from the column at various points and are stripped in side-strippers before being removed as products (Liebmann et al., 1998).

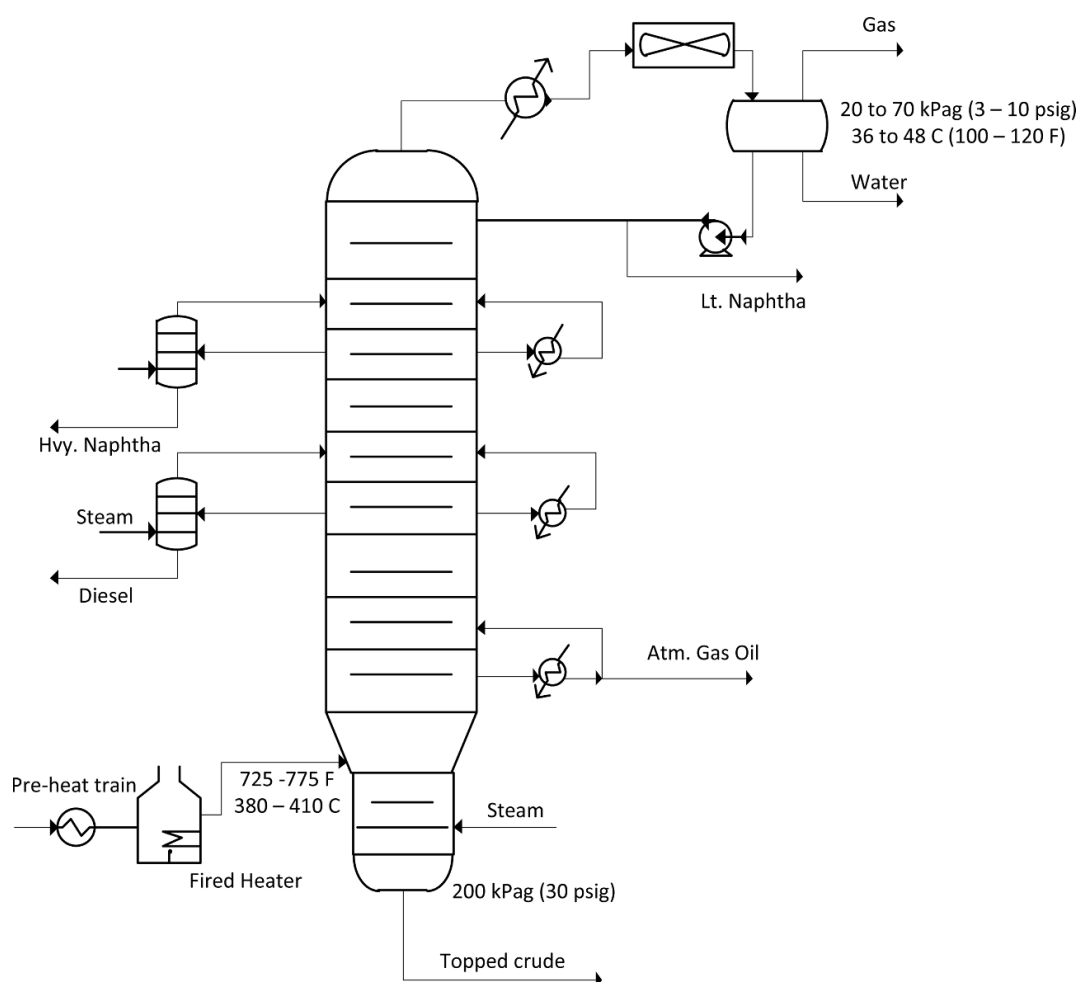


Figure (14)
Typical Flow of Refinery Atmospheric Distillation Unit (Chang et al., 2012)

There are two mechanisms commonly used to vaporize light components from the liquid in strippers, namely; steam stripping and reboiling. Liebmann et al. (1998) stated that the fundamental principles of vaporization are quite different in the two cases, so the choice of stripping medium has a significant impact on the utility requirements of the column. Table 2 summarizes the main differences between the two mechanisms.

Table (2)
Comparison between Stripping Steam and Reboiling (Liebmann et al., 1998)

	Stripping Steam	Reboiling
Description	Direct injection of superheated low-pressure steam	Heating liquid hydrocarbon in reboiler using heating medium.
Mechanism	Steam reduces the partial pressure of the hydrocarbons in the vapor phase and therefore vaporize light component at lower temperature	Raising the temperature of hydrocarbon will vaporize the light components.
Temperature profile	An inverse temperature profile in the stripper, where the liquid on the bottom stage is cooler than the liquid on the stage above it.	Regular temperature profile in the stripper, where the bottom stripper stage will have higher temperature than the one above.
Energy efficiency	Higher efficiency where a small fraction of the material is required to vaporize.	Reboiling is generally more energy efficient and has higher potential for heat recovery than steam stripping.
Environment	Direct contact between steam and hydrocarbon will result in production of foul water, which need to be processed to remove impurities.	No direct contact between heating medium and hydrocarbon.
Capital cost	Low capital cost	High capital cost due to equipment installation.
Operating cost	Higher cost due to; corrosion inhibitors, processing of foul water.	Lower operating cost.

Distillation or boiling points curves is a widely used method to characterize oil samples or hydrocarbon product. These curves represent the temperature profile against the cumulative volume percent of hydrocarbon sample as shown in Figure 15. There are several types of boiling point curves, such as true boiling point curve (TBP), American Society for Testing and Materials (ASTM) D86, ASTM D1160, ASTM D2887, etc. The differences between these types of curves are that they are measured using different equipment and under different conditions. These data are essential to simulate oil processing units in computer aid software such as HYSYS® (Chang et al., 2012).

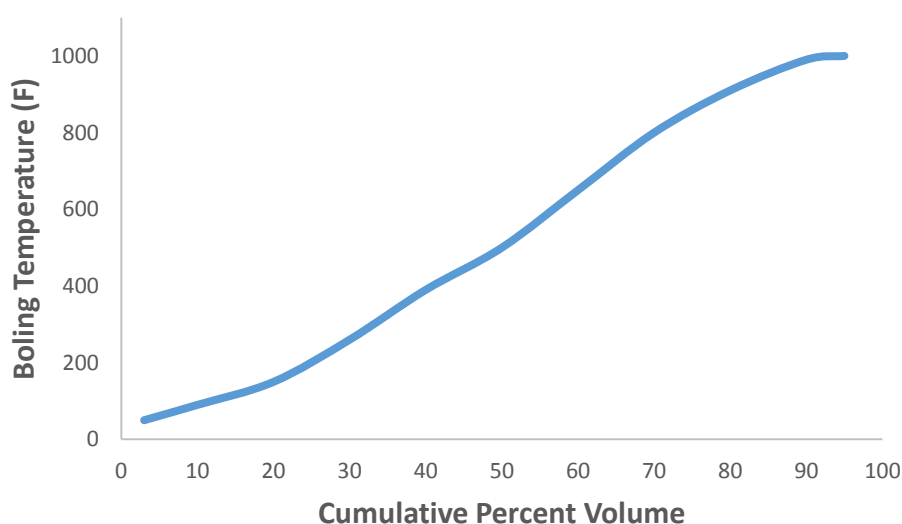


Figure (15)
Typical Crude oil Distillation Curve (Chang et al., 2012)

Chang et al. (2012) presented systematic steps of simulation and optimization of key oil processing units such as atmospheric distillation unit, using the commercial software Aspen HYSYS® from Aspen Technology, Inc. This software is a popular process simulation tool for

refining and chemical plants. In addition, this software has the capability to perform energy analyses to different design alternatives. Modeling of an existing atmospheric crude distillation unit was discussed by Chang et al. (2012), including relevant data collection and validation. This model is going to be used as the base design of proposed case study. Table 3 summarizes the design parameters of the base case of the crude oil distillation unit.

Table (3)
Design Parameters of Base Case (Chang et al., 2012)

Feed /Product	Stage	Flow rate (ton/day)	Condition
Crude Feed	26	21000	3.0% Overflash
Bottoms Steam	28	289.4	Saturated @ 250C
Off Gas	Condenser	N/A	60 C
Light Naphtha	Condenser	3549	60 C
Residue	Bottoms	11375	349 C
Side Strippers	Draw rate (ton/day)	Steam (Kg/hr)	Draw / Return
Heavy Naphtha	921	1313	10/9
Kerosene	13333	1243	17/16
LGO	3822	3418	22/21
Pumparound	Flow rate (ton/hr)	Duty (GCa/hr)	Draw / Return
Heavy Naphtha	376.1	-13.9	10/9
Kerosene	234.9	-9.1	17/16
LGO	298.1	-12.2	22/21

Pinch analysis is a useful design methodology for practical engineers for heat exchange systems. This methodology can lead to better process design through systematic consideration of energy consumption capital investment and emission. Aiming to demonstrate how to apply alternative heat integration approaches, recover the maximum waste heat and maintain stable production, Goodarzvand-Cheghini et al. (2011) conducted a study to

retrofit typical hydrocracking process at Tehran South Refinery. Data were collected and utilized to simulate the process in Aspen HYSYS® software. Then Heat Exchanger Network (HEN) were optimization through SUPERTARGET® software. The study came up with several energy reduction opportunities that result in \$870 000 annual savings in energy costs.

Implementation of PI in chemical processes can play a major role in energy saving and emission reduction for existing systems. Zhang et al. (2013) presented a systematic strategy to implement PI in chemical processes to improve the environmental performance of existing facilities without major capital expenditure. Execution strategy was applied on heat recovery of commercial crude distillation unit in China. Pinch analysis was employed to analyze the current operation of HEN and adjustments were taken accordingly. The result has shown a reduction of energy consumption of 8% without capital expenditure.

While performing the proposed case study for this research, the following features should be taken into consideration; the process of the unit consumes energy to heat up the feed, produce energy with product streams, and release emissions associated with consumed fuel. These features are applicable for atmospheric distillation unit.

Pinch analysis implemented by Goodarzvand-Chegini et al. (2011) and Zhang et al. (2013) is going to be applied on crude oil distillation unit. Moreover Part of Goodarzvand-Chegini et al. (2011) approach is going to be employed in the case study where crude distillation is going to be simulated using HYSYS® then energy analyses is going to be conducted to benchmark generated alternatives.

Chang et al. (2012) scope covered atmospheric distillation unit, but the preheat train or heat exchanger network was simulated as single heat exchanger which does not reflect the real life condition. Present case study attempt to expand the scope of Chang et al. (2012) by designing the HEN and benchmark different alternatives based on fuel gas consumption and flue gas emissions. Provided case study will demonstrate how minimizing fuel gas consumption and reduction of emissions from utility systems can be achieved by applying PI. Moreover, energy analyses will be conducted to facilitate the selection among to alternative designs of atmospheric distillation unit one with stripping steam and other with reboilers.

2.4 Literature Review Summary

This chapter provided a theoretical overview of the topics covered by the present study. It was divided in to three main pillars which were; framework of sustainable oil and gas project management in Bahrain, evaluation of the role of EIA in energy saving and emission reduction, and a case study about applying PI to oil processing unit to achieve energy conservation and reduction of emissions.

Project life cycle stages were outlined as well as stages of typical EIA process. More emphasis was given to the legal and institutional contexts of the Kingdom of Bahrain. Several studies about the alignment between projects life cycle and environmental tools (i.e. EIA and EMS) were summarized and discussed.

The role of EIS review in enhancing EIA practice was covered. Furthermore, examples of EIS reviews were provided. In addition, studies about EIS review in the Kingdom of Bahrain were summarized. Covered

literatures revealed that although energy consumption and air emissions are significant environmental aspect in Bahrain, the role of EIA to address these aspects in the was not investigated.

Overview about PI was given and the key steps of this engineering method were outlined. In addition, the role of PI to overcome the limitation of generation and selection alternatives was presented. Proposed case study about utilizing PI as an enabling tool for EIA was generally described.

Chapter Three

Methods and Procedures

3.1 Framework of Sustainable Project Management for Oil and Gas Projects in Bahrain

To achieve the first objective of this study, Bahrain's environmental regulations were investigated. In addition, Bapco's environmental standards and procedures of oil and gas projects were explored. These legal texts were converted into process flow charts to illustrate each stage of environmental tools (EIA and EMS) and project cycle (CPDEP). Synchronization of developed flow charts will be performed to present the current framework of incorporation environmental tools with oil and gas projects cycle in the Kingdom of Bahrain.

Microsoft Visio software will be used to construct process flow diagrams. This helps in visualizing the entire framework of environmental tools aligned with project cycle. All CPDEP phases are to be shown in parallel with each associated step of environmental tools.

Environmental regulations are available for the public on the website of the Bahrain's Legislation and Legal Opinion Commission (LLOC, 2015). Environmental procedures for oil and gas projects were obtained from Bapco. Table 4 lists the documents used to construct the framework.

Table (4)
Legislations and Standards Used to Construct the Framework

Bahrain's Environmental Regulations
Ministerial Order No. 1 of 1998 with Respect to Environmental Evaluation of Projects.
Resolution of Minister of Housing, Municipalities and Environment No. 3 of 2000 on the adoption of consulting firms operating in the field of environmental assessment for projects and environmental studies.
Bapco's Standards
Environmental assessment of engineered projects.
Environmental management system manual.
Identification and evaluation of environmental aspects and impacts.

3.2 The Role of EIA in Minimizing Energy Consumption and Emission Reduction in Bahrain

In order to evaluate the role of practiced EIA in Bahrain toward energy saving and reduction of emission, eight EIA reports (Table 5) were obtained officially from the SCE and Bapco. The initial scope was to evaluate EIA reports that belonged to oil and gas sector in order to be consistence with first objective. Whereas due to the limited number of EIA reports in the oil and gas sector, the scope was broaden to include all available EIA reports that belong to energy intensive projects such as; electrical power plants, chemical process units, aluminum plant, and steel plant. These projects represent the main industrial projects in Bahrain for the last ten years.

Three main environmental statement review packages are to be explored namely; environmental statement review package by Lee et al. (1999), the Guidance on environmental statement review by EC (2001), and the environmental statement review package by Oxford Brookes University (Glasson et al., 2005). Table 6 provides a summary of the topics and subheading of these commonly used review packages.

Table (5)
Selected EIA Reports

No.	Project	Activity
1	ALBA expansion project	Aluminum smelting
2	GARMCO expansion project	Aluminum rolling mill
3	AL-EZZEL power plant	Power generation
4	AL-DUR power plant	Power generation
5	Waste water treatment plant at Bapco	Oily waste water treatment
6	YATEEM CO ₂ plant	Production of CO ₂
7	Low sulfur diesel plant at Bapco	Oil processing
8	SULB Integrated steel complex	Steel processing

Table (6) Summary of Commonly Used Environmental Review Packages

Oxford Brooks University	Lee and Colley	EU
1. Description of the development • Principal features of the project • Land requirements • Project inputs • Residues and emissions 2. Description of the environment. • Description of the area occupied by and surrounding the project. • Baseline conditions 3. Scoping, consultation, and impact identification. • Scoping and consultation • Impact identification 4. Prediction and evaluation of impacts. • Prediction of magnitude of impacts • Methods and data • Evaluation of impact significance 5. Alternatives. 6. Mitigation and monitoring. • Description of mitigation measure • Commitment to mitigation and monitoring • Environmental effects of mitigation 7. Non-technical summary 8. Organization and presentation of information • Organization of the information • Presentation of information • Difficulties compiling the information	1. Description of the development, the local environment and the baseline conditions: • Description of the development • Site description • Residuals • Baseline conditions 2. Identification and evaluation of key impacts: • Identification of impacts • Prediction of impact magnitudes • Assessment of impact significance 3. Alternatives and mitigation: • Alternatives • Mitigation • Commitment to mitigation 4. Communication of results: • Presentation • Balance • Non-technical summary	1. Description of the project • The Objectives and Physical Characteristics of the Project • The Size of the Project • Production Processes and Resources Used • Residues and Emissions • Risks of Accidents and Hazards 2. Consideration of alternatives 3. Description of environment likely to be affected by the project • Aspects of the Environment • Data Collection and Survey Methods 4. Description of the likely significant effects of the project • Scoping of Effects • Prediction of Direct Effects • Prediction of Secondary, Temporary, Short Term, Permanent, Long Term, Accidental, Indirect, Cumulative Effects • Prediction of Effects on Human Health and Sustainable Development Issues • Impact Assessment Methods 5. Description of mitigation 6. Non-technical summary 7. Quality of presentation

Environmental guidelines related to the EIA process in Bahrain are limited (Naser, 2012). SCE has a set of guidelines only for frequent projects such as desalination plants and reclamation activities. Therefore, specific criteria to systematically review EIA reports of energy intensive projects are to be formulated. These criteria can be utilized to evaluate the role of EIA in energy conservation and emission reduction. Energy and emission related questions are to be extracted from explored review packages check lists to develop evaluation criteria. Some general questions will be modified to suite energy field. In addition, guide for assessing energy use and greenhouse gas emissions in an environmental impact statement by NYSDEC (2009) is to be utilized as well. Developed equations are to be grouped into two main categories; energy and emissions.

To facilitate evaluation of the reports, quality indexes can be used. The index enables quantification of the qualitative answers to the review questions. Söderman (2005), Khera and Kumar (2010) and Naser (2015) implemented similar quality index to rate the quality of the EIA reports in different areas. Quality index is going to be calculated for each category of equations i.e. energy and emissions. These indexes reflects the overall quality of a report in documenting energy consumption and air emissions. The quality index is identified by equation number 1:

Equation (1)
Quality index

$$QI = \frac{A+0.5B}{Q-NA}$$

QI: Quality Index.

A: Number of review questions fully met.

B: Number of review questions partially met.

Q: Total number of review questions.

NA: Not applicable questions.

According to this formula, the value of the quality index may vary from 0 if none of the review check list questions is met and 1 if all review questions are fully met. The reviewed EIA reports will be grouped based on the scores of the quality index as follows. QI between 0.0 and 0.25 (poor), 0.26 and 0.50 (borderline), 0.51 and 0.70 (satisfactory), and 0.71 and 1.00 (good) (Naser, 2015).

Although using such index is useful for overall comparison of the EIA quality, but comparing overall scores can hide the relative strengths or weaknesses of the different criteria areas. In addition, Söderman (2005) stated that this approach has extra limitations. These limitations are; the index evaluate only reported issued not actual process, and the index is subjective and the results reflect the evaluator's understanding of what constitutes a satisfactory treatment of a review question.

Table (7)
Evaluation Criteria for the Role of EIA in Energy Conservation and Emission Reduction

Area of evaluation	Emissions Questions	Energy Questions
1. Description of the project • The size of the project • Production processes and energy used • Residues and emissions	1.1. Are the types and quantities of gaseous and particulate emissions associated with energy use by the project identified? (emissions from combustion of fossil fuels in stationary and mobile plant, emissions from traffic) • during construction • during operation • during decommissioning	1.1. Are the types of energy sources and quantities of energy required by the project identified? • during construction • during operation • during decommissioning
	1.2. Are the locations for discharge of all emissions to air identified and the characteristics of the discharges identified? (e.g. height of stack, velocity and temperature of release)	1.2. Are all the energy consumption processes involved in operating the Project described? (e.g. manufacturing or engineering processes, primary raw material production)
	1.3. Are the quantities of emissions associated with energy consumption per unit of outputs produced by the project described and benchmarked with national or international standard? (presented in terms of KG/ppm per unit mass or volume , etc.) (emission intensity index)	1.3. Are the quantities of energy per unit of outputs produced by the project described and benchmarked with national or international standard? (presented in terms of energy per unit mass or volume , etc.) (energy intensity index)
	1.4. Are the methods for collecting, treating and finally discharging these emissions to air described?	1.4. Is the potential for resource recovery from wastes and residues discussed? (including re-use, recycling or energy recovery process or heat integration) 1.5. Is efficiency in use of energy and raw materials discussed?
	1.5. Are the methods for estimating the quantities and composition of all residues and emissions identified and any difficulties discussed?	1.6. Are the methods for estimating the quantities of energy consumption identified and any difficulties discussed?
2. Consideration of alternatives	2.1 Are emissions associated with energy use considered as one of the criteria for choosing between alternatives?	2.1 Are energy type and quantity considered as one of the criteria for choosing between alternatives?

3. Description of environment likely to be affected by the project - Aspects of the environment - Data collection and survey methods	3.1 Are the current emissions associated with energy use within the area of project described?	3.1 Is the current energy use within the area of project described?
	3.2 Have all relevant national and local agencies been contacted to collect information about the baseline of air emissions?	3.2 Have all relevant national and local agencies been contacted to collect information about the baseline of energy use?
	3.3 Where surveys have been undertaken to characterize the air quality baseline, are the methods used, any difficulties encountered and any uncertainties in the data described?	3.3 Where surveys have been undertaken to characterize the baseline of energy use, are the methods used, any difficulties encountered and any uncertainties in the data described?
	3.4 Were the methods used appropriate for the purpose?	3.4 Were the methods used appropriate for the purpose?
	3.5 Are any important gaps in the data on the existing air quality identified, and the means used to deal with these gaps during the assessment explained?	3.5 Are any important gaps in the data on the existing energy use identified, and the means used to deal with these gaps during the assessment explained?
	3.6 If surveys would be required to adequately characterize the baseline of air quality but they have not been practicable for any reason, are the reasons explained and proposals set out for the surveys to be undertaken at a later stage?	3.6 If surveys would be required to adequately characterize the baseline of energy use but they have not been practicable for any reason, are the reasons explained and proposals set out for the surveys to be undertaken at a later stage?
4. Description of the likely significant effects of the project - Prediction of direct effects - Prediction of secondary, temporary, short term, permanent, long term, accidental, indirect, cumulative effects - Impact assessment methods	4.1 Are direct, primary effects on air quality described and where appropriate quantified?	4.1 Are direct, primary effects on energy use described and where appropriate quantified?
	4.2 Where effects are evaluated against legal standards or requirements, are appropriate local, national or international standards used and relevant guidance followed?	4.2 Where effects are evaluated against legal standards or requirements, are appropriate local, national or international standards used and relevant guidance followed?
	4.3 Are positive effects on the environment described as well as negative effects?	4.3 Are positive effects on the environment described as well as negative effects?
	4.4 Are the methods used to predict effects described, and are the reasons for their choice, any difficulties encountered and uncertainties in the results discussed?	4.4 Are the methods used to predict effects described, and are the reasons for their choice, any difficulties encountered and uncertainties in the results discussed?
	4.5 Where there is uncertainty about the precise details of the project and its impact on the environment are worst case predictions described?	4.5 Where there is uncertainty about the precise details of the project and its impact on the environment are worst case predictions described?

5. Mitigation and monitoring. • Description of mitigation measure • Commitment to mitigation and monitoring • Environmental effects of mitigation	4.6 Is the basis for evaluating the significance or importance of impacts clearly described?	4.6 Is the basis for evaluating the significance or importance of impacts clearly described?
	4.7 Are cumulative effects on the environment of the project together with other existing or planned developments in the locality described?	4.7 Are cumulative effects on the environment of the project together with other existing or planned developments in the locality described?
	5.1 Where there are significant adverse effects from air emissions is the potential for mitigation of these effects discussed?	5.1 Where there are significant adverse effects from energy use is the potential for mitigation of these effects discussed?
	5.2 Are the measures which the developer proposes to implement to mitigate effects clearly described and is their effect on the magnitude and significance of impacts clearly explained?	5.2 Are the measures which the developer proposes to implement to mitigate effects clearly described and is their effect on the magnitude and significance of impacts clearly explained?
	5.3 If the effect of mitigation measures on the magnitude and significance of impacts is uncertain is this explained?	5.3 If the effect of mitigation measures on the magnitude and significance of impacts is uncertain is this explained?
	5.4 Are the Developer's reasons for choosing the proposed mitigation explained?	5.4 Are the Developer's reasons for choosing the proposed mitigation explained?
	5.5 Are responsibilities for implementation of mitigation including funding clearly defined?	5.5 Are responsibilities for implementation of mitigation including funding clearly defined?
	5.6 Where mitigation of significant adverse effects is not practicable or the developer has chosen not to propose any mitigation are the reasons for this clearly explained?	5.6 Where mitigation of significant adverse effects is not practicable or the developer has chosen not to propose any mitigation are the reasons for this clearly explained?
	5.7 Are arrangements proposed to monitor and manage residual impacts?	5.7 Are arrangements proposed to monitor and manage residual impacts?
	5.8 Are any negative effects of the proposed mitigation described?	5.8 Are any negative effects of the proposed mitigation described?
	5.9 Do mitigation measures linked to the environmental management plan?	5.9 Do mitigation measures linked to the energy management plan?

Evaluation criteria in the present study are to be divided in to 5 review areas; namely description of the project, consideration of alternatives, description of environment likely to be affected by the project, description of the likely significant effects of the project and mitigation and monitoring. These areas were subdivided in to 28 review questions for emissions and 29 for energy as shown in Table 7.

3.3 Process Integration as an Enabling Tool for EIA

As mentioned earlier, the aim of the case study is to demonstrate how PI can be utilized as enabling tool for the common area between CPDEP and EIA process i.e. generate and select alternatives. The case study is going to give an example of minimizing fuel consumption and enhancing pollution prevention by conducting energy analyses for two alternatives designs for atmospheric distillation units.

Atmospheric distillation has features that make it appropriate option which are; the process consumes energy to heat up the feed, produce energy as heated product streams, and release emissions associated with consumed fuel. Applying PI will enhance the energy efficiency and reduce the emissions.

An approach for comparative analyses and evaluations of the two alternatives designs for vaporizing light ends in side strippers; stripping steam and reboilers is presented in this section. The approach mainly contains the following steps: data collection, process simulation, product quality validation, energy analysis for each alternative design, estimating of possible emissions. Figure 16 summarizes the followed approach which was modified from Gu et al. (2014).

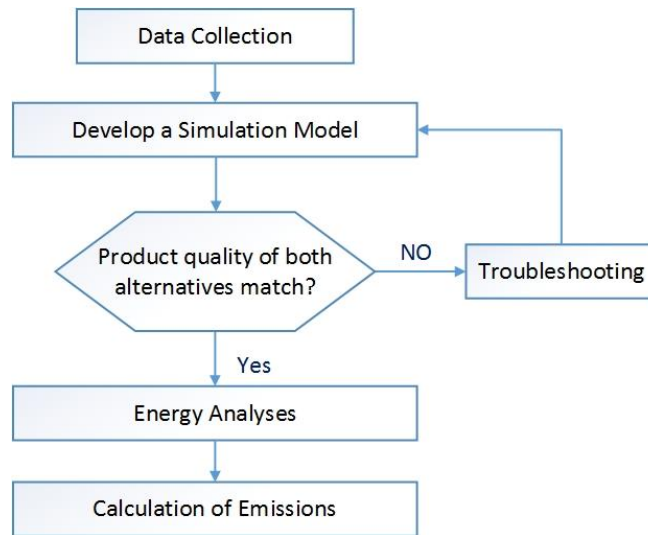


Figure (16)
The Analysis and Evaluation Procedure

In the first step process data will be extracted from the design parameters by Chang et al. (2012). A simulation model is to be constructed using Aspen HYSYS® for both alternative designs. In order to ensure that both options will give same products quality, both distillation curves and flow rates of products will be compared. Troubleshooting and adjustment to the design variables is to be done in case of any deviation between the two alternatives. The next step is to import process streams to Aspen Energy Analyzer® to perform energy analyses by drawing grid diagram for both alternatives and determine energy requirement for each design. Emissions can be estimated by multiplying the amount of required fuel gas with emission factor of each type of pollutants. These factors were estimated based on gas composition data for natural gas (khuf gas).

Chapter Four

Results, Discussion, Conclusion and Recommendations

4.1 Framework of Sustainable Project Management for Oil and Gas Projects in Bahrain

4.1.1 Results

Result of the alignment between implemented project life cycle for oil and gas projects and EIA process in the Kingdom of Bahrain is illustrated in Figure 17. The following section of the result will give an overall description to the framework. The initiation of EIA procedure for oil and gas projects is left largely at the discretion of the project engineering team. In some cases, the procedure can be requested very early when the project is still at the conceptual design stage.

Project engineering team and environmental management section at the company shall decide whether the project fall within the engineered project that needs EIA or not. If “YES”, screening phase of EIA process should be started by preparation of SCE screening form (Appendix 4). In case of “NO”, the project can go ahead without any further environmental review or assessment.

Screening form should be submitted to the Directorate of Environmental Assessment and Monitoring at the SCE which might ask for additional information about the proposed project. Then SCE shall decide whether EIA is required or not. If EIA is not required, the project shall proceed on that basis. In case of required EIA, project engineering team shall include this requirement in their project’s agenda and carry on with EIA procedure. According to ministerial order No.3 of 2000 with respect to adoption of EIA consulting firms and environmental studies, EIA study should be carried out through an approved consulting firm.

The consultant shall prepare and submit scoping report to both project proponent and SCE. The report should follow the SCE guidelines for each type of industrial activity. After completion of scoping study, report is reviewed by SCE which might ask for modifications or further information.

In general, scoping report discusses significant issues to be included in the EIA, specifies the boundaries of assessment and establishes the environmental baseline of possibly effected aspects of environment.

At scoping phase of EIA is carried out in parallel to second phase of project life cycle where consideration of alternatives is the main concern. Two types of alternatives can be distinguished. First, alternatives to a proposed action, for example; a retrofit for existing oil processing unit or construction of new one, or changing the site of a proposed project. Additionally, there are alternatives within a proposed action, such as alternative processes, layouts on site or other design aspects.

When scoping report is accepted by SCE, consultant can proceed to evaluation phase of the EIA process, where the impact is predicted, the significance of the impact is determined, and impact mitigation and management are proposed. Environmental impact study should be documented and submitted to SCE for review.

As per the ministerial order No.1 of 1998 with respect to environmental evaluation of projects, EIA report should contain the following main elements; a complete and precise description of the project, justifications for establishing the project from an economic and social perspective, objectives of the project, project establishment stages, results of execution of the project on natural resources and safety in particular, procedures to be adopted to protect the environment, the program in place

for detecting emissions resulting from the project, comprehensive description of the environmental baseline which may be affected by the project in the projects' area, and details of the environmental interactions with the project during all stages of the project execution.

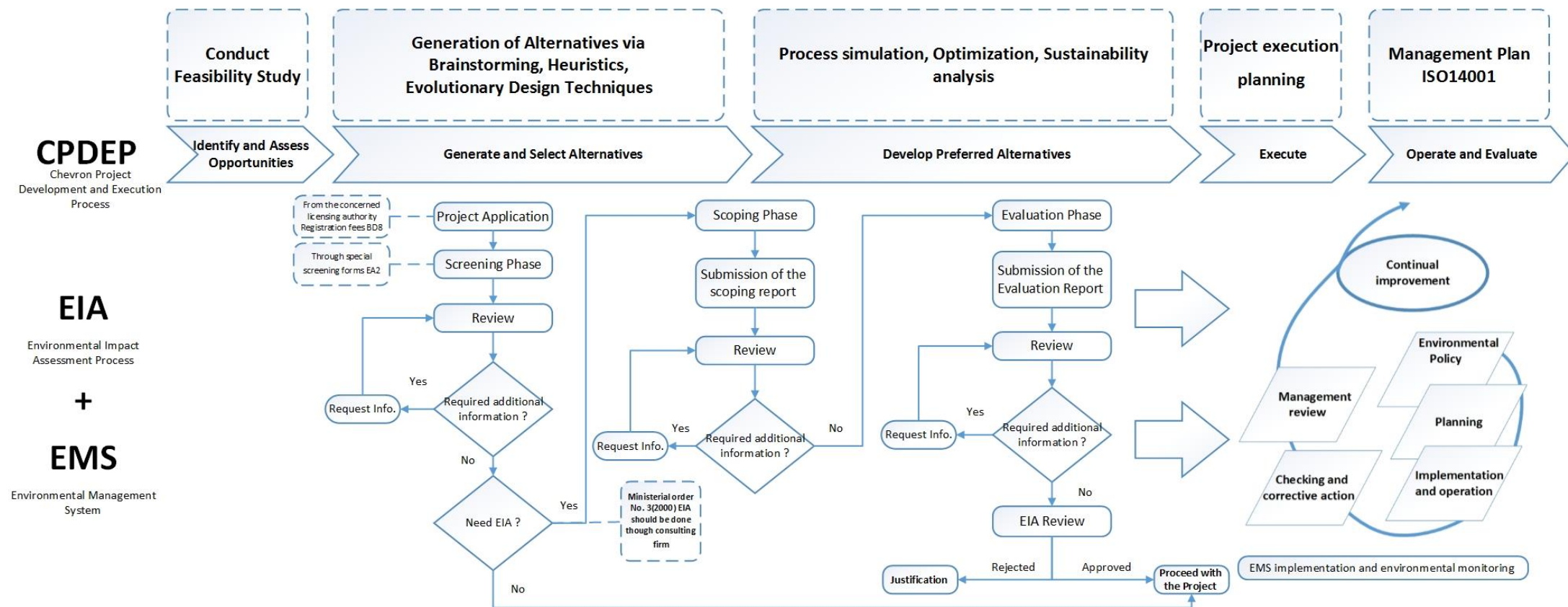


Figure (17)
Framework of Environmental Tools and Project Cycle of Oil and Gas Sector in Bahrain

In all cases the review of EIS shall be completed before the end of the CPDEP Phase 3 i.e. development of preferred alternative. SCE usually form multidisciplinary team to review the EIA study prior to decide whether to approve or reject the proposed development project.

The outcomes of EIS should translate the mitigation measures to environmental management plan. The current practice in Bahrain is the results of EIS are to be fed to the planning stage of implemented EMS.

Bapco has been accredited for internationally recognized EMS ISO 14001 since 2009, ISO 14001 is a mean to facilitate and incorporate sound environmental management as part of an organization's overall management strategy. The key components of ISO 14001 as presented in Figure 17 are; environmental policy, planning, implementation and operation, checking and corrective actions, and management review. These components shall ensure continual environmental improvement. Implementation of EMS starts at fourth phase and continued throughout the fifth phase of CPDEP (operate and evaluate).

4.1.2 Discussion

Brown and Hill (1995), Lohani et al. (1997), and Ridgway (1999) studies paid an attention to the importance of the interaction between environmental tools (EIA and EMS) and projects life cycle. However, their approaches and models were general and ignored the specific requirements of each type of projects. Brent and Petrick (2007) were able to narrow the scope of the alignment to meet the specific requirements of raw materials processing industry in the energy sector and to put it within the context of specific legal and institution obligations of South Africa.

The common hypothesis of reviewed literatures is that alignment between environmental tools (EIA and EMS) with project life cycle can contribute positively to the practice of these tools and promote the integrity of environment. The present study shared the same concern and presented an alignment between projects life cycle on one hand and environmental tools on the other hand. The scope of work was specified to suit oil and gas sector in the Kingdom of Bahrain. Such work has not been done before and can be considered as new contribution.

EIA legislations in Bahrain were investigated. Environmental standards and procedures of oil and gas projects of national oil and gas company Bapco were explored. Reviewed documents were converted to process flow charts to illustrate each stage of environmental tools (EIA and EMS) and implemented project life cycle approach (CPDEP). A framework has been developed to illustrate stated objective. The presented framework in Figure 17 is essential step to analyze and evaluate the practice of EIA for oil and gas sector which will contribute to strengthen of EIA process and overcome the shortcomings.

The framework reflects a thorough consideration of environmental aspects throughout projects life cycle of oil and gas sector in the Kingdom of Bahrain. Moreover, oil and gas activities have been framed with set of legislations and quality documents that ensure the consideration of environmental aspects and guide both Bapco and the environmental executive body i.e. SCE. Presented framework showed that second phase of project cycle is parallel to the scoping phase of EIA process, which reflects a good potential to empower the consideration and the discussion about possible alternatives to achieve development objectives and consider environmental aspects.

It has been proposed that linking between EMS and EIA enables a more comprehensive approach to environmental management where shortcomings in the EIA process can be addressed by the EMS process and vice versa. Moreover, EMS can fulfill the role of EIA follow up (Hollands and Palframan, 2014). The framework represents clearly that mitigation measures should be translated to management plan, which is prepared at the stage of EIA and enforced at stage of execution.

Most of oil and gas projects are energy intensive and required specific attention to both energy consumption and associated emissions. Although ministerial order No.1 of 1998 stated that the EIA report should include a description of any possible increase in the demand of nonrenewable resources, there are no specific legal instruments that address the efficient use of energy for the proposed projects. This clearly indicates an area of improvement within the environmental legislations in Bahrain. Bridging this gap could be achieved through cooperation between relevant official authorities such as; Ministry of Energy, SCE, and legislation authorities to establish set of legislations and guidelines to ensure the efficient use of energy within industrial premises.

On the other hand, air emissions that are associated with the use of fossil fuel are covered legally by ministerial Order No. 10 of 1999 with respect to environmental standards (air and water) and its subsequent amendments.

Up to this point, we can summarize that environmental aspects have been considered thorough the life cycle of oil and gas projects. Moreover, legislations in Bahrain have taken in to account the permissible limits of air emissions associated with the use of energy for industrial activities. However, a gap has been identified with respect to legislations that ensure

efficient use of energy for these activities. That brought us to the next part of the study where we try to evaluate the current practice of EIA in minimizing energy consumption and emission reduction in Bahrain.

4.2 The Role of EIA in Minimizing Energy Consumption and Emission Reduction in Bahrain

4.2.1 Results

4.2.1.1 Quality Indices

The overall quality of evaluated EIA reports, in considering air quality aspects and emissions reduction is presented in Figure 18. The majority of the reports reflected a good consideration of air quality in the environmental studies whereas two reports categorized as satisfactory.

On the other hand, Figure 19 represents the overall quality of evaluated EIA reports, in considering efficiency and energy consumption aspects. Half of the reports were assessed as borderline. Two reports were categorized as satisfactory compared with two of poor quality.

Generally, emissions and air quality aspects were covered and discussed in more details, whereas energy aspects have got less focus. All evaluated reports have allocated separate section for air quality assessment whereas, only two reports have devoted special sections to cover efficient operation and energy consumption matters.

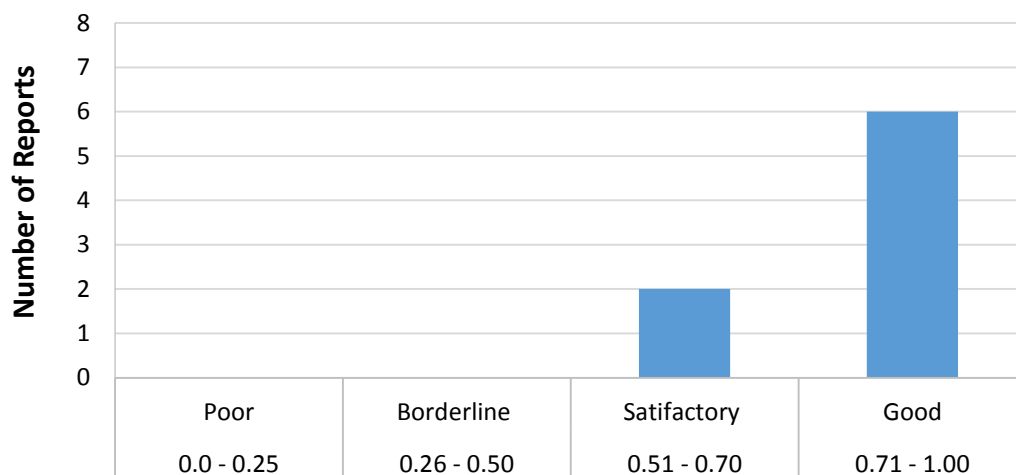


Figure (18)
Emissions Quality Index

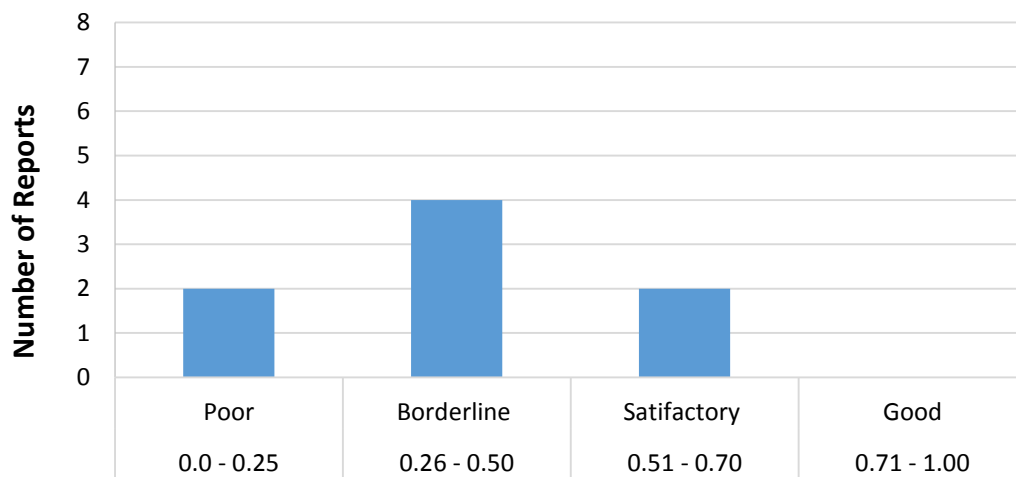


Figure (19)
Energy Quality Index

All reviewed EIA reports were evaluated using the evaluation criteria listed in chapter three Table 7. Evaluation criteria represent the following main topics; description of the project, consideration of alternatives, description of environment likely to be affected by the project, description of the likely significant effects of the project, and mitigation and monitoring. The obtained results are shown in following results tables. Criteria results could be 0: not met, 0.5 partially met 1: fully met or NA: not applicable. For detailed results, see evaluation sheets (Appendix 5).

4.2.1.2 Description of the Project

Table (8)
Evaluation Results for Description of the Projects

Emissions Questions	Result				Energy Questions	Result			
	0	0.5	1	N/A		0	0.5	1	N/A
1.1. Are the types and quantities of gaseous and particulate emissions associated with energy use by the project identified? (emissions from combustion of fossil fuels in stationary and mobile plant, emissions from traffic) - during construction - during operation - during decommissioning		2	6		1.1. Are the types of energy sources and quantities of energy required by the project identified? - during construction - during operation - during decommissioning	1	4	3	
1.2. Are the locations for discharge of all emissions to air identified and the characteristics of the discharges identified? (e.g. height of stack, velocity and temperature of release)		1	7		1.2. Are all the energy consumption processes involved in operating the Project described? (e.g. manufacturing or engineering processes, primary raw material production)		3	5	
1.3. Are the quantities of emissions associated with energy consumption per unit of outputs produced by the	5	1	2		1.3. Are the quantities of energy per unit of outputs produced by the project described and benchmarked with	6	1	1	

project described and benchmarked with national or international standard? (presented in terms of KG/ppm per unit mass or volume , etc.) (emission intensity index)					national or international standard? (presented in terms of energy per unit mass or volume , etc.) (energy intensity index)				
1.4. Are the methods for collecting, treating and finally discharging these emissions to air described?			8		1.4. Is the potential for resource recovery from wastes and residues discussed? (including re-use, recycling or energy recovery process or heat integration)	1		7	
					1.5. Is efficiency in use of energy and raw materials discussed?	1		7	
1.5. Are the methods for estimating the quantities and composition of all residues and emissions identified and any difficulties discussed?		3	5		1.6. Are the methods for estimating the quantities of energy consumption identified and any difficulties discussed?	8			

The main purpose of this section in EIA report is to give the decision makers a clear idea about the details of proposed development project. The scope of the majority of evaluated EIA reports was to study environmental impacts of both construction and operation phases. Only one report has cover decommissioning environmental impact while others stated that decommissioning phase will need standalone environmental study.

The majority of the reports (75%) were good in identifying types and quantities of gaseous and particulate emissions associated with energy use or from the process of the project. Air emissions were listed in tables with predicted quantities for different operation scenarios. There were some limitations on the other (25%) of the reports in covering the amount of emissions due to energy use of the industrial facility.

All of the reports described the methods for collecting, treating and finally discharging emissions to air. In addition, the locations for discharge

of all emissions to air were identified. The characteristics of the discharges were identified as well (e.g. height of stack, velocity and temperature of release) and used to for dispersion models.

Although all of the reports specified the types of fuel to be used, there were gaps in quantifying the amount of energy during construction phase. Five of the evaluated reports described energy consumption processes involved in operating the project very well. For instance, one of the reports listed all process units and gave precise numbers about required energy quantities and fuel gas rates before and after project execution. On the other hand, the other three provided general description with less details of quantities.

Energy intensity index is a measure of the energy efficiency and can be used as an indicator to establish benchmarking which is one of the tools for energy audit (Klemes et al., 2010). In same context, emission intensity index is an indicator of how environment friendly the project is (IChemE, 2002). Six of the evaluated reports failed to quantify energy and emissions per unit of outputs produced by the project. Only three provided necessary information (i.e. production rate, energy consumption rate, and emissions rates) to calculate such indexes. Only two reports provided good examples of utilizing either energy or emissions intensity indexes to evaluate the efficiency of the project and benchmark it with those from other regions.

Efficiency in the use of energy and raw materials were discussed somehow in most of the reports (88%). These discussions varied from engineering configuration of the plants which included; type of technology, overall efficiency of the plant, potential of heat recovery, and use of low NO_x burners reaching to simple energy conservation measures such as switching of the unwanted lightings.

Methods for estimating the quantities and composition of all residues and emissions were identified and discussed in all of the reports. Moreover, six of the reports conducted dispersion models to characterize the quantities and direction of emitted air pollutants i.e. NO_x, SO_x, gashouse fluoride etc. One of the reports stated that air dispersion modeling should be conducted before starting plant operation. Unlike emissions, methods for estimating the quantities of energy consumption were not discussed for all of the reports. Material and energy balance approaches were not covered instead only numbers of the required materials and energy were given.

4.2.1.3 Consideration of Alternatives

Table (9)
Evaluation Results of Consideration of Alternatives

Emissions Questions	Result				Energy Questions	Result			
	0	0.5	1	N/A		0	0.5	1	N/A
2.1 Are emissions associated with energy use considered as one of the criteria for choosing between alternatives?	2	1	5		2.1 Are energy type and quantity considered as one of the criteria for choosing between alternatives?	2	2	4	

As discussed in chapter two the consideration of alternatives is an essential part of both CPDEP and EIA procedures. At this stage, a comprehensive approach has to be followed to investigate the most appropriate technology, design, process and location for a proposed project.

Seven of the evaluated projects use natural gas as source of energy and one of them utilized electricity from the national grid. Four reports

considered energy as a criterion for choosing between alternatives in good way, which include technologies, plant designs or equipment selection. In context, six reports took into account emissions as evaluation criteria as well. The results show that two reports did not cover energy or emission aspects while judging the alternatives.

As reported by Naser (2015) most of the projects in Bahrain were in late stages of implementation and their sites were allocated or purchased by the project proponents upon before the EIA is commenced. This condition was reflected in one of the reports where, the cumulative impact of that project is likely to cause exceedance of the annual mean standard for a major pollutant but the decision was to proceed with the project.

4.2.1.4 Description of Environment Likely to be Affected by the Project

Table (10)
Evaluation Results for the Description of Environment Likely to Be Affected by the Project

Emissions Questions	Result				Energy Questions	Result			
	0	0.5	1	N/A		0	0.5	1	N/A
3.1 Are the current emissions within the area of project described?		2	6		3.1 Is the current energy use within the area of project described?	3	1	4	
3.2 Have all relevant national and local agencies been contacted to collect information about the baseline of air emissions?	1	1	6		3.2 Have all relevant national and local agencies been contacted to collect information about the baseline of energy use?	4	1	1	

3.3 Where surveys have been undertaken to characterize the air quality baseline, are the methods used, any difficulties encountered and any uncertainties in the data described?		1	5	2	3.3 Where surveys have been undertaken to characterize the baseline of energy use, are the methods used, any difficulties encountered and any uncertainties in the data described?	3			5
3.4 Were the methods used appropriate for the purpose?		3	3	2	3.4 Were the methods used appropriate for the purpose?				8
3.5 Are any important gaps in the data on the existing air quality identified, and the means used to deal with these gaps during the assessment explained?	1		5	2	3.5 Are any important gaps in the data on the existing energy use identified, and the means used to deal with these gaps during the assessment explained?	3		1	3
3.6 If surveys would be required to adequately characterize the baseline of air quality but they have not been practicable for any reason, are the reasons explained and proposals set out for the surveys to be undertaken at a later stage?	2		1	5	3.6 If surveys would be required to adequately characterize the baseline of energy use but they have not been practicable for any reason, are the reasons explained and proposals set out for the surveys to be undertaken at a later stage?	7		1	

The main purpose of the description of likely affected environment is to establish a baseline that could be used as reference when evaluating the significance of the effects. Eventually, all EIA reports addressed the current emissions conditions with some variations.

Half of the reviewed reports included new meteorological surveys. Details of surveying and sampling methods were presented adequately, and were justified to suite the purpose of the study. Furthermore, difficulties encountered were discussed most of the times. For example, one of the EIA reports presented the results of short-term survey and stated that these data are not enough to characterize the baseline environment so further surveys

should be conducted to have full data about background air quality throughout the year.

Most of the reports utilized meteorological data from Bahrain International Airport at Muharraq, which has a record of these data since 1980s (Al Bahrana and Al Mahdi, 1991). In addition, all reports utilized baseline information from the automatic air quality monitoring network that has been installed since 1993 by General Directorate of Environment & Wildlife Protection. The air quality monitoring network consisted of three fixed stations, then updated with five modern mobile stations distributed around the Kingdoms' governorates.

Three EIA reports failed to cover the current energy use within the development projects' area, while other reports vary from giving general statements about the surrounding industrial activities to detailed figures about types and quantities of energy consumption. Although evaluated reports are for major energy consumers and producers, no numbers were given about the contribution of each facility in the national energy or fuel consumption rate.

4.2.1.5 Description of the Likely Significant Effects of the Project

Table (11)
Evaluation Results of the Description of the Likely Significant Effects of The Project

Emissions Questions	Result				Energy Questions	Result			
	0	0.5	1	N/A		0	0.5	1	N/A
4.1 Are direct, primary effects on air quality described and where appropriate quantified?		1	7		4.1 Are direct, primary effects on energy use described and where appropriate quantified?	5	1	2	
4.2 Where effects are evaluated against legal standards or requirements, are appropriate local, national or international standards used and relevant guidance followed?			8		4.2 Where effects are evaluated against legal standards or requirements, are appropriate local, national or international standards used and relevant guidance followed?	7			1
4.3 Are positive effects on the environment described as well as negative effects?			4	4	4.3 Are positive effects on the environment described as well as negative effects?				8
4.4 Are the methods used to predict effects described, and are the reasons for their choice, any difficulties encountered and uncertainties in the results discussed?		1	7		4.4 Are the methods used to predict effects described, and are the reasons for their choice, any difficulties encountered and uncertainties in the results discussed?	3			5
4.5 Where there is uncertainty about the precise details of the project and its impact on the environment are worst case predictions described?	1		4	3	4.5 Where there is uncertainty about the precise details of the project and its impact on the environment are worst case predictions described?				8
4.6 Is the basis for evaluating the significance or importance of impacts clearly described?		2	6		4.6 Is the basis for evaluating the significance or importance of impacts clearly described?	3		1	4

4.7 Are cumulative effects on the environment off the project together with other existing or planned developments in the locality described?	2		6		4.7 Are cumulative effects on the environment off the project together with other existing or planned developments in the locality described?	7	1		
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All of reports provided adequate description of the primary effect on air quality and seven of them presented quantified estimations of the effect.

Dispersion modeling is a predictive tool used to calculate the concentration of pollutants at sensitive receptors resulting from known sources of air pollution. Six of the evaluated reports performed such modeling to characterize the primary impact on air quality. Four reports carried out the modeling using an advanced dispersion model software called AERMOD, which was developed by the US Environmental Protection Agency (Gibson et al., 2013). One used ADMS Urban software while other one did not mention the type of software used to perform the desperation modeling.

Input data to dispersion models were presented clearly on tables for different operation scenarios including the worst case. Consequently, the results illustrated using aerial maps, which gave clear idea about the dispersion behavior of the emitted air pollutants.

Methods used to predict effects on air quality were described in all of the reports. The common used approach was to sum background pollution concentrations with anticipated emissions from the proposed project.

In many cases uncertainty about the precise details of the project impact on the environment are faced. Therefore, the worst case scenarios encounter to predict the most conservative impact on the air quality. Four

of the evaluated reports presented the effect at different scenarios and presented the predictions of the worst cases.

All of the reports evaluated the effects of air quality against Ministerial Order No. 2 of 2001 Amendments to Ministerial Order No. 10 of 1999 with Respect to Environmental Standards (Air and Water). Fifty percent of the reports went further and reference to other international standards such as World Bank standards for air quality.

The basis for evaluating the significance of impacts on air quality were described in all of the reports, six of them were clearly presented while the other two of them got partially met due to unclear presentation.

According to conducted review, half of the proposed projects have positive effects on environment. That is due to either purpose of the project or retrofit of existing facility that would contribute to the reduction in the current rate of emissions.

Energy-wise five of the evaluated reports failed to describe the primary effect on energy use. On the other hand, only two reports were able to give quantitative assessment to the impact of project on energy demand. Moreover, none of the reports referred to appropriate local, national or international standards or relevant guidance to evaluate the effect of energy use.

Only one report scored good in terms of clearly describing the basis for evaluating the significance of impacts of energy use regarding duration, intensity, probability, and significance.

An EIA study should include all significant impacts and interactions and particular care may need to be taken in identifying cumulative effects

(Abaza et al., 2004). The majority (75%) of the reports covered the cumulative effects on air quality together with other existing developments in the locality clearly, where the current concentrations of air pollutants were summed to the anticipated amount from the proposed projects. In addition, lack of considering possible future project can be noticed while covering the cumulative impact assessment. On the other hand, the majority (88%) of the reports failed to evaluate the cumulative impact of energy use. Only one report covered this issue but it was limited to the effect of the proposed development on the overall energy demand of the company.

4.2.1.6 Mitigation and Monitoring

Table (12)
Evaluation Results for Mitigation and Monitoring

Emissions Questions	Result				Energy Questions	Result			
	0	0.5	1	N/A		0	0.5	1	N/A
5.1 Where there are significant adverse effects from air emissions is the potential for mitigation of these effects discussed?			8		5.1 Where there are significant adverse effects from energy use is the potential for mitigation of these effects discussed?	1		7	
5.2 Are the measures which the developer proposes to implement to mitigate effects clearly described and is their effect on the magnitude and significance of impacts clearly explained?		4	4		5.2 Are the measures which the developer proposes to implement to mitigate effects clearly described and is their effect on the magnitude and significance of impacts clearly explained?	1	3	5	
5.3 If the effect of mitigation measures on the magnitude and significance of impacts is uncertain is this explained?			2	6	5.3 If the effect of mitigation measures on the magnitude and significance of impacts is uncertain is this explained?	1			7

5.4 Are the Developer's reasons for choosing the proposed mitigation explained?	1		6	1	5.4 Are the Developer's reasons for choosing the proposed mitigation explained?	3		4	1
5.5 Are responsibilities for implementation of mitigation including funding clearly defined?	2		6		5.5 Are responsibilities for implementation of mitigation including funding clearly defined?	7		1	
5.6 Where mitigation of significant adverse effects is not practicable or the developer has chosen not to propose any mitigation are the reasons for this clearly explained?	1	1	2	3	5.6 Where mitigation of significant adverse effects is not practicable or the developer has chosen not to propose any mitigation are the reasons for this clearly explained?	1			7
5.7 Are arrangements proposed to monitor and manage residual impacts?	1	1	6		5.7 Are arrangements proposed to monitor and manage residual impacts?	8			
5.8 Are any negative effects of the proposed mitigation described?				8	5.8 Are any negative effects of the proposed mitigation described?				8

Both mitigation of adverse effects and monitoring of residual impacts are crucial steps in the EIA process. All of the reports discussed mitigation measures to minimize the impact on air quality whereas four of them were not clear in terms of the effect of these measures on the magnitude and significance of impacts. The majority (75%) of the reports justified the reasons of proposed mitigations.

Mitigation measures included several aspects such as; improved ventilation system, better stack designs and commitment to operate according to the principles of best available techniques and considering opportunities for cost-effective improvement.

The arrangements proposed to monitor and manage residual impacts were described in the most of the reports (88%). Proposed arrangements included implementation of continuous emission monitoring systems, which give real time data about emitted pollutants. Such system ensure the compliance with specific stack emission limit values.

Most of the reports (88%) included mitigation measures to minimize energy consumption the measures are considered at the early stage of design of technology selection such as; production method , the use of ultra NOx burners, combined cycle power plant configuration, or the use of heat recovery systems.

4.2.1.7 Environmental Management Plan

Table (13)
Evaluation Results for Environmental Management Plan

Emissions Questions	Result				Energy Questions	Result			
	0	0.5	1	N/A		0	0.5	1	N/A
5.9 Do mitigation measures linked to the environmental management plan?		1	7		5.9 Do mitigation measures linked to the energy management plan?	7	1		

Integration of EIA with EMS can achieve the environmental quality goals of both EIA and EMS because it ensures that adverse impacts are anticipated and controlled, and any remaining significant impacts are reduced or eliminated through a continuous improvement cycle. Integrated process should help to improve environmental quality and sustainable development (Eccleston and Smythe, 2002).

One of the EIA requirements by the SCE guidelines is to provide information about environmental management plan and arrangements. This requirement was reflected positively in the evaluated reports where six of the reports included the proposed management plans. These plans were linked to mitigation measures. In addition, two reports were for companies that already have established EMS and certified with internationally recognized environmental management system ISO14001.

On the other hand, one of the reports discussed the plan but it was not included in the EIA study and only one report failed to link between EIA and environmental management plan.

In contrast to air quality, there is no legal requirement that enforce project proponent to include energy management plan within EIA report. So none of the evaluated reports linked mitigation measures to energy management plan. Only one of the reports suggested developing and implementing an energy management program to reduce the amount of energy consumed by the plant and to ensure all the equipment efficiency is optimized.

4.2.2 Discussion

Energy consumption and CO₂ emissions have been increasing substantially during the past 27 years in the Kingdom of Bahrain (Jafari et al., 2015). That highlight the need for energy conservation strategies and a carbon emissions reduction policy. In the Kingdom of Bahrain, EIA process is the implemented practice to ensure considering environmental aspects for proposed development projects. Different aspects of EIA process has been evaluated (Naser et al., 2008, Naser, 2015). However, the

role of this process toward energy conservation and emission reduction have not been investigated. The present study aimed to investigate this uncovered area and provide an initial step for further researches. To be in consistence with first pillar of the study, the primary scope was to evaluate EIA reports related to oil and gas projects. However, due to limited number of available reports the scope was expanded to include all available reports of projects that involve intensive use of energy and have the potential for air emissions.

Developed evaluation criteria from Lee et al. (1999), EC (2001) and Glasson et al. (2005) were used to conduct quality review for selected EIA reports according to the method developed by Söderman (2005), Khera and Kumar (2010) and Naser (2015).

The main findings of conducted assessment revealed that the current practice of EIA in Bahrain gives more emphasizing on the aspects of air quality where evaluated reports either classified as good or satisfactory quality. Whereas, shortcoming has been identified in the consideration of energy aspects. Limitations were observed in the main parts of EIA reports i.e. description of the project, description of environment likely to be affected, description of primary environmental impact, and monitoring of residual impact.

The good consideration of air quality aspects can be ascribed to environmental laws in Bahrain (Ministerial Order No. 10 of 1999) which require the monitoring of air emissions and wastewater effluents for the large industrial facilities. On the other hand, there are no legal obligations in the EIA related laws and regulations for energy management to ensure efficient use of energy.

EIA is provided for the level of individual projects, whereas significant environmental issues should be addressed at a higher level of planning (Thompson et al., 2013). Moreover, SEA is powerful tool that can be apply for energy planning (De Montis, 2014). In addition, Naser (2015) recommended adopting strategic environmental assessment to enhance the current practice of EIA in Bahrain. In contrast, all evaluated EIA reports were focused on environmental aspects for the level of individual projects only, and none of them was linked to SEA. This highlight the need for enforcing SEA practices in Bahrain and link it to energy strategic planning. It should be note that lack of SEA implementation to energy sector is a worldwide challenge (Jay, 2010).

Environmental regulation has an important role in enhancing EIA practice and maintaining environmental resources. As reported by Naser (2015) Bahrain has achieved significant progress in developing a legal framework for EIA system that specifies duties and responsibilities of relevant bodies involved in the EIA process. Bahraini environmental law that requires the monitoring of air emissions and that was reflected positively in the evaluated reports. Whereas, lack of legislations that consider the energy aspects and its efficient use can describe limited weight of this aspect within evaluated reports. Enact legislations or provide set of guidelines to monitor energy consumption for industrial activities will contribute to better consideration of efficient energy use in EIA studies.

The current EIA practice in Bahrain revealed a strong link between EIA reports and environmental management plans. Whereas, energy aspects were not translated to management plans. This reflects an area of improvement, where adopting energy management system is an effective measures to proper energy management and enhance conservation of energy within industrial premises (Dörr et al., 2013).

Energy management system ISO 50001 is an internationally recognized system and a profound measures for proper energy management and enhance conservation of energy within industrial premises (Ates and Durakbasa, 2012, Dörr et al., 2013, Dzene et al., 2015, Gopalakrishnan et al., 2014, Jovanović and Filipović, 2016). In general, an energy management system should consist of energy policy with strategic and operational energy goals as shown in Figure 20 followed by implementation and evaluating the progress against these goals to take corrective actions. Management review should be performed periodically to ensure the continual improvement and efficient utilization of energy sources.

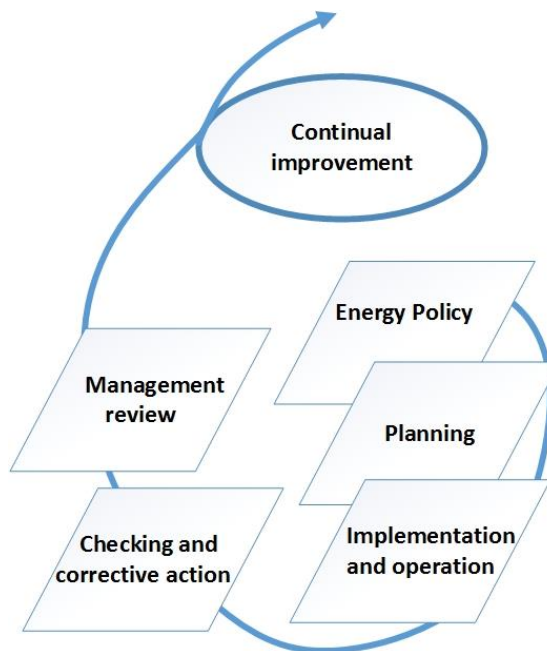


Figure (20)
Energy Management System ISO50001

4.3 Process Integration as an Enabling Tool for EIA

4.3.1 Results

Atmospheric crude distillation unit has been simulated using Aspen HYSYS. Figure 21 and Figure 22 show the completed distillation column simulation on Aspen HYSYS for both design alternatives.

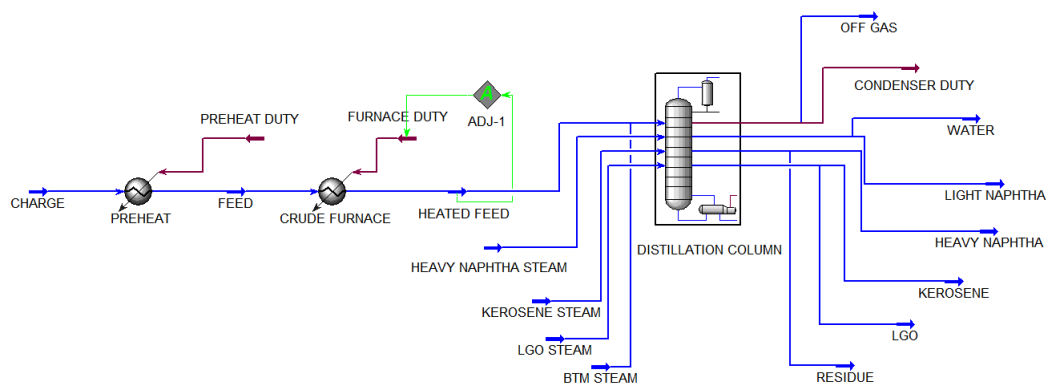


Figure (21)
HYSYS Simulation of Atmospheric Crude Distillation Column Base Case

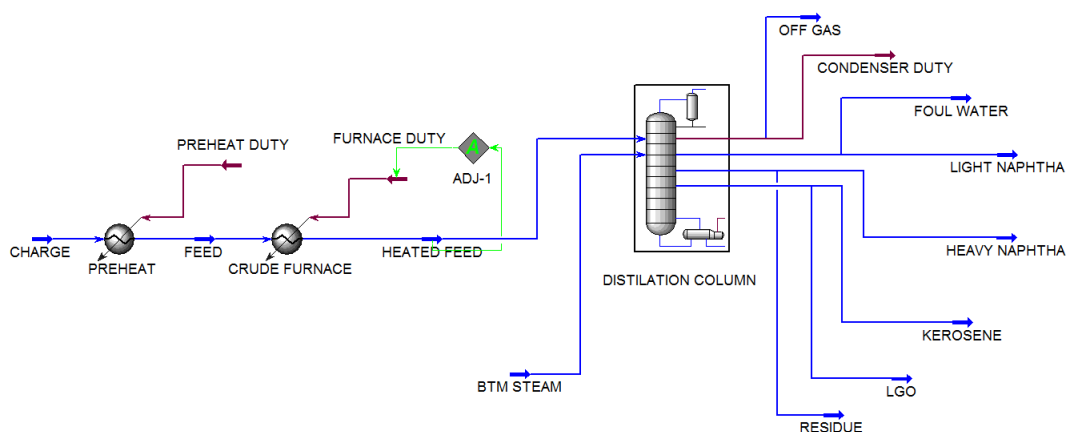


Figure (22)
HYSYS Simulation of Atmospheric Crude Distillation Column 2nd Alternative

Products flow rates obtained from both alternatives are presented in Figure 23. It can be noticed that products flow rates for both designs are the same with minor differences. Most importantly, produced foul water has been reduced substantially by about 37% in case of reboilers instillation due to the reduction of stripping steam.

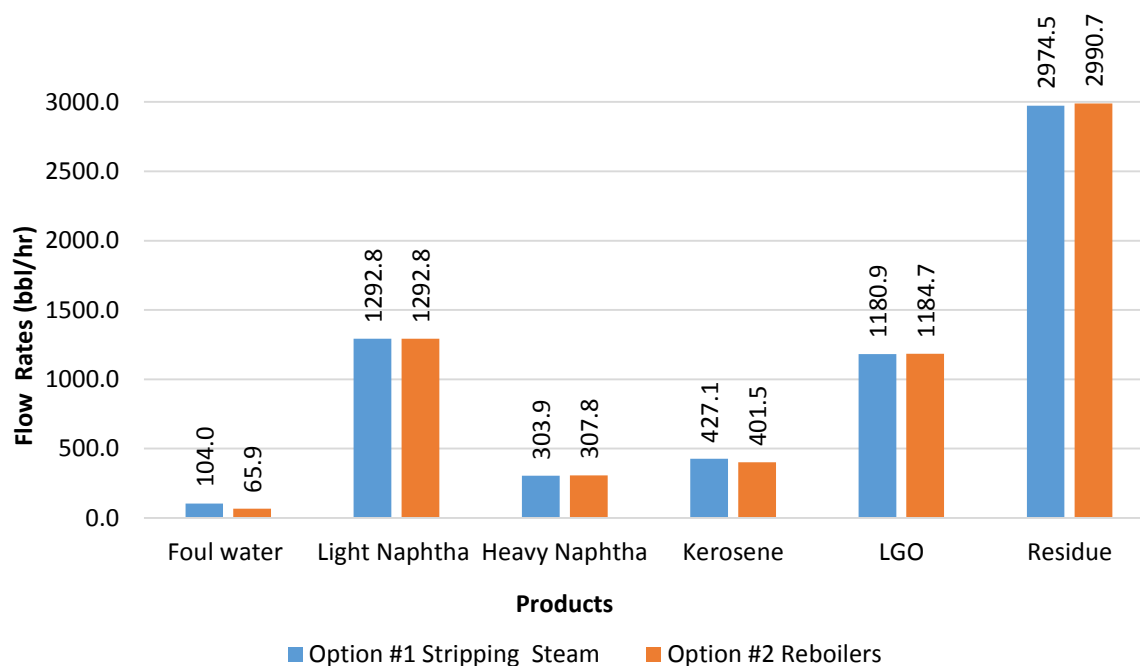


Figure (23)
Products Flow Rates for Both Alternative Designs.

To ensure both designs can give same product quality distillation curves were plotted and presented in Figures 24 to 27. It is clear that both options stripping steam and reboilers will give similar product quality.

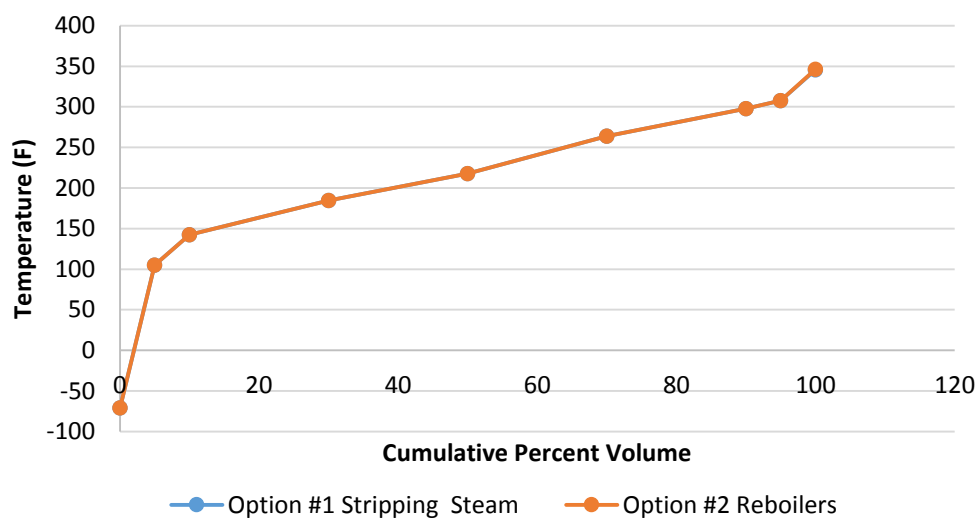


Figure (24)
Light Naphtha Distillation Curve for Both Alternatives

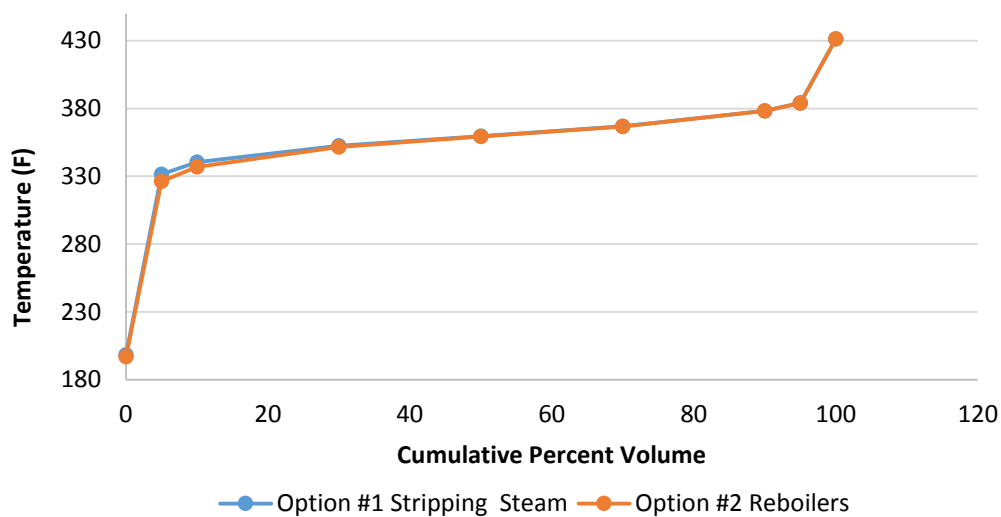


Figure (25)
Heavy Naphtha Distillation Curve for Both Alternatives

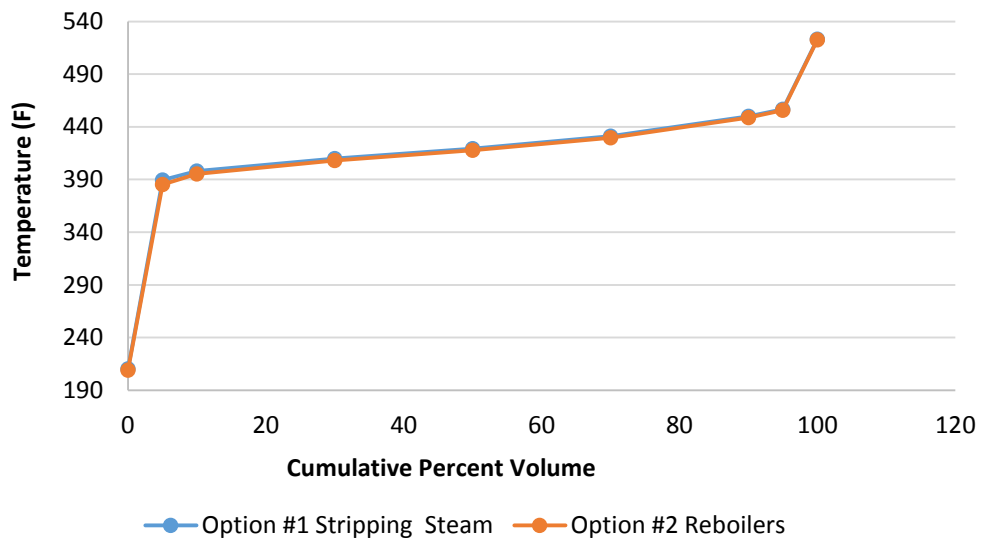


Figure (26)
Kerosene Distillation Curve for Both Alternatives

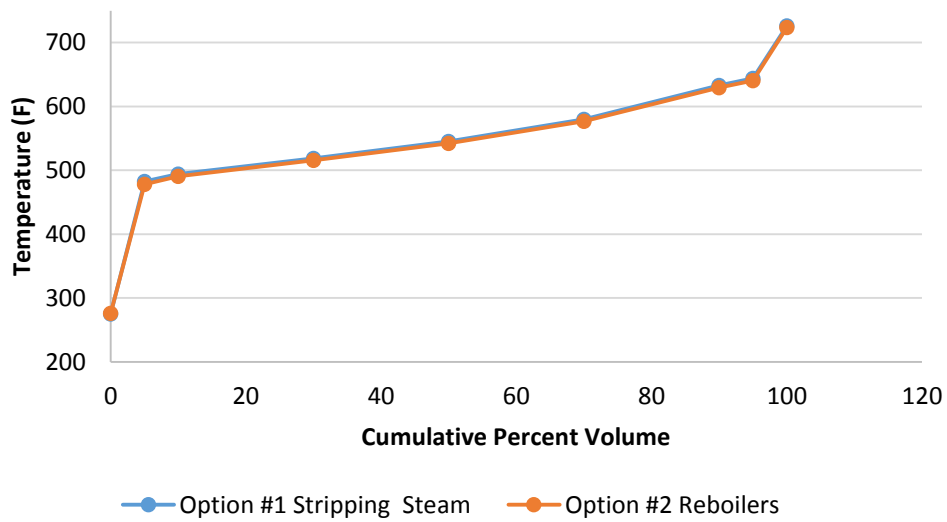


Figure (27)
LGO Distillation Curve for Both Alternatives

Since products quality validation step was satisfied, energy analyses can be performed. Process streams were imported from developed simulation to Aspen Energy Analyzer to analyse the potential of heat exchange between cold and hot streams. Tables 14 and 15 present process streams, supply temperatures, target temperatures and the duties of both alternatives. Process flow diagram of each alternative is illustrated in Figures 28 and 29.

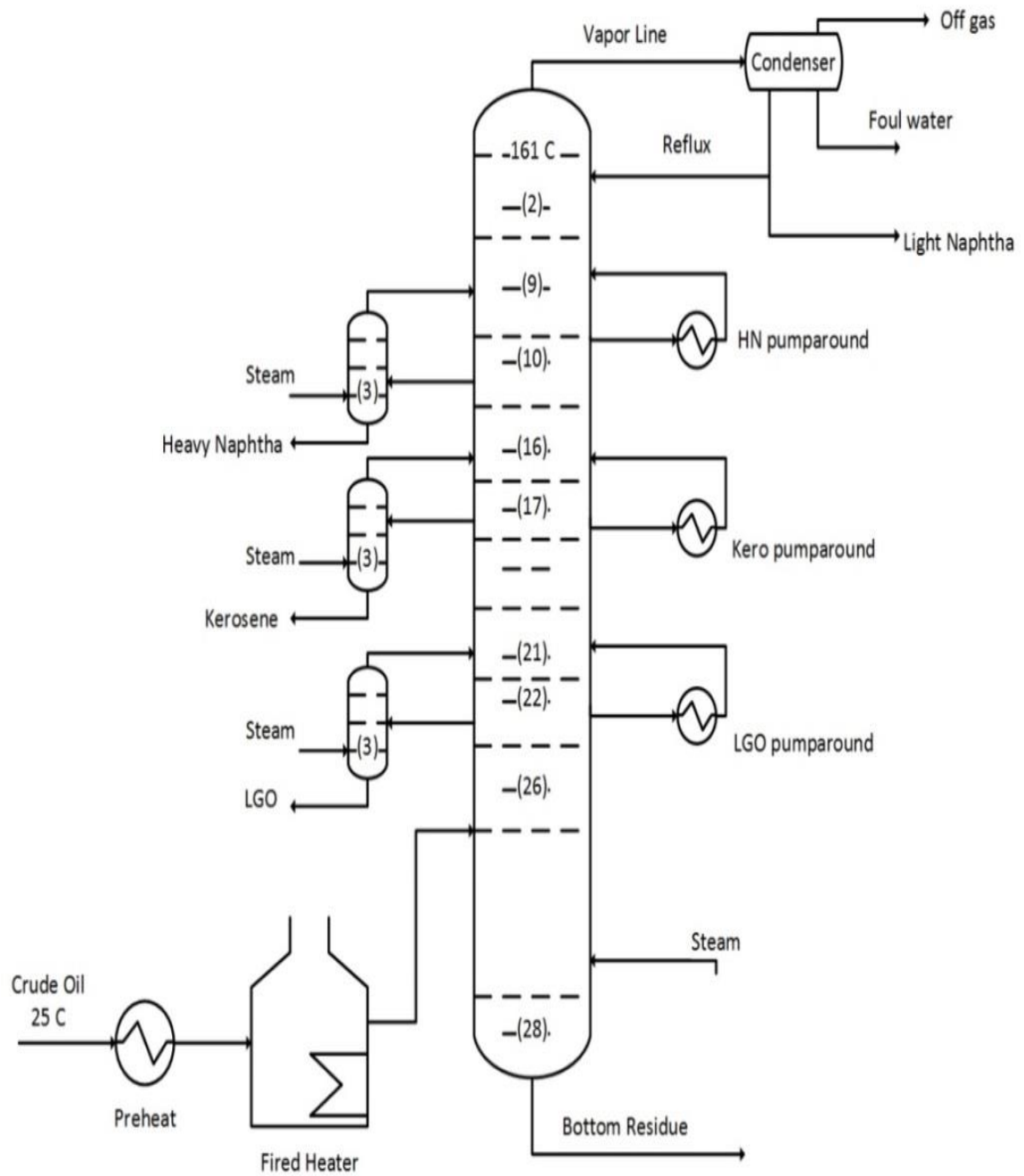


Figure (28)
Process Flow Diagram of Stripping Steam Alternative

Table (14)
Supply and Target Temperatures, Duties of Process Streams and Stripping
Steam (First Alternative)

Stream	Supply Temp (F)	Target Temp (F)	Duty (MMBTU)
Light Naphtha (LN)	150.7	110	-7.33
Heavy Naphtha (HN)	343.2	110	-11.32
Kerosene	417.7	110	-21.97
Light Gas Oil (LGO)	515.9	110	-85.21
Residue	663.6	110	-327.14
HN Pump Around	395.5	233.5	-83.56
Kerosene Pump Around	460.9	352.9	-36.81
LGO Pump Around	552.1	444.1	-48.43
Vapor line (Condenser)	298.6	150.7	-198.67
Crude Feed	59	693	819.79
HN Stripping Steam			3.37
Kero Stripping Steam			3.19
LGO Stripping Steam			8.77
BTM Stripping Steam			29.78

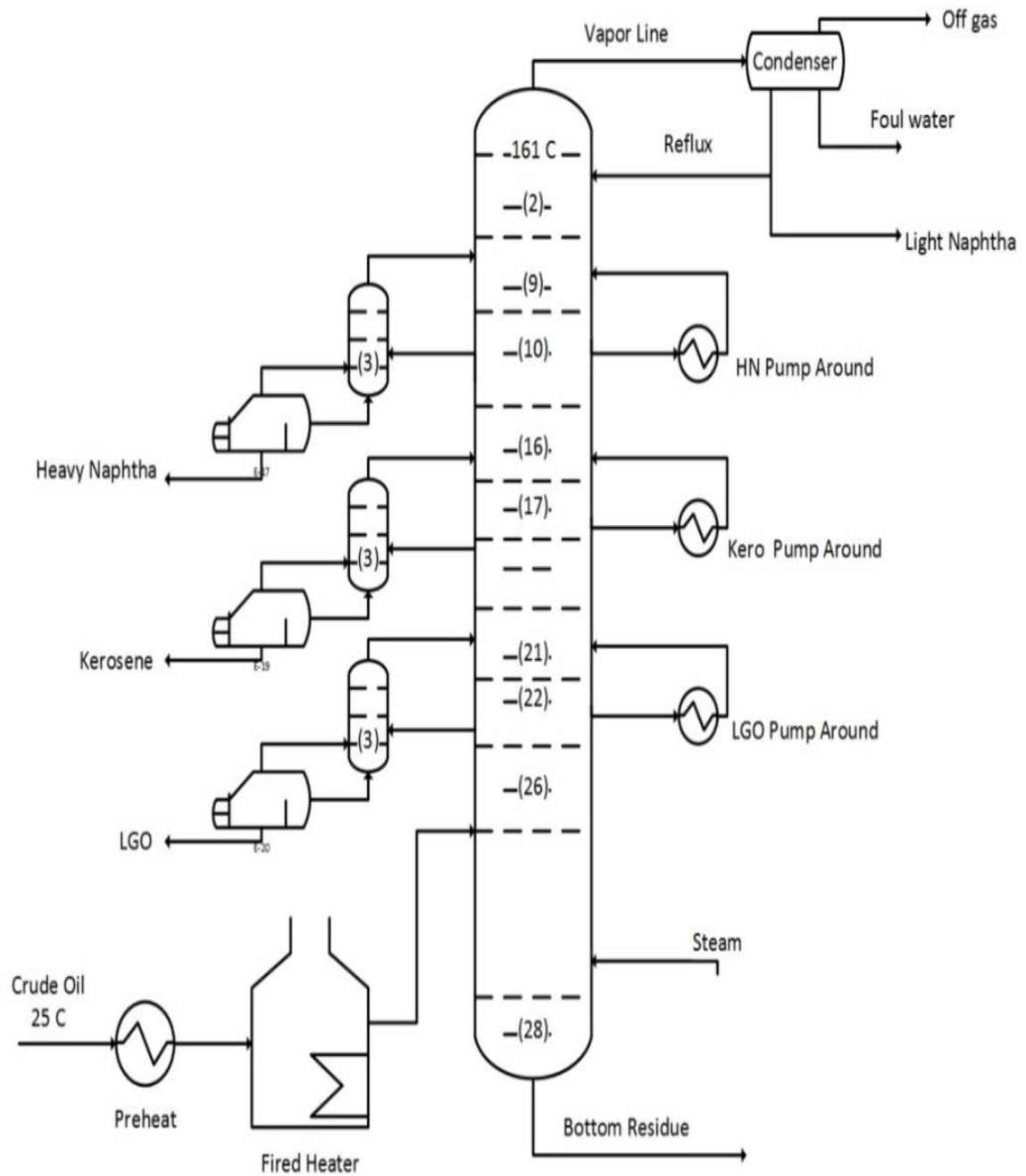


Figure (29)
Process Flow Diagram of Reboilers Alternative

Table (15)
Supply and Target Temperatures, Duties of Process Streams and Reboilers
(Second Alternative)

Stream	Supply Temp (F)	Target Temp (F)	Duty (MMBTU)
Light Naphtha (LN)	150.4	110	-7.28
Heavy Naphtha (HN)	433.6	110	-15.82
Kerosene	502	110	-28.25
Light Gas Oil (LGO)	621.8	110	-112.16
Residue	663	110	-328.41
HN Pump Around	397.6	235.6	-83.71
Kerosene Pump Around	462.5	354.6	-36.85
LGO Pump Around	554.1	446.1	-48.47
Vapor line (condenser)	303.7	150.4	-172.28
Crude Feed	59	693	819.79
HN reboiler			3.84
Kero reboiler			5.53
LGO reboiler			22.76
BTM Stripping Steam			29.78

Composite curves were generated using Aspen Energy Analyzer as shown in Figures 30 and 31. These curves reflect that applying heat integration could contribute to exchange of up to 80% of the required heat to raise the temperature of crude oil feed. Energy analyses showed that the maximum heat exchange between cold and hot streams is 667.8 MMBTU (81.5% of the required heat) for first option and 694.1 MMBTU (84.7% of the required heat) for the second. This revealed that the potential for heat recovery is higher for the reboilers alternative.

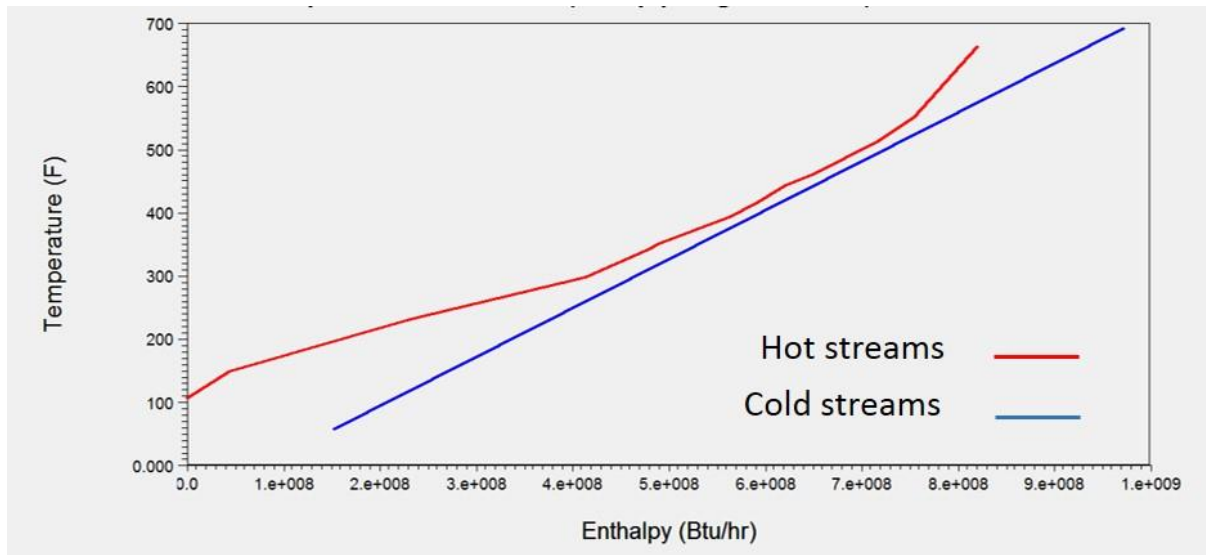


Figure (30)
Composite Curves of First Alternative (Stripping Steam)

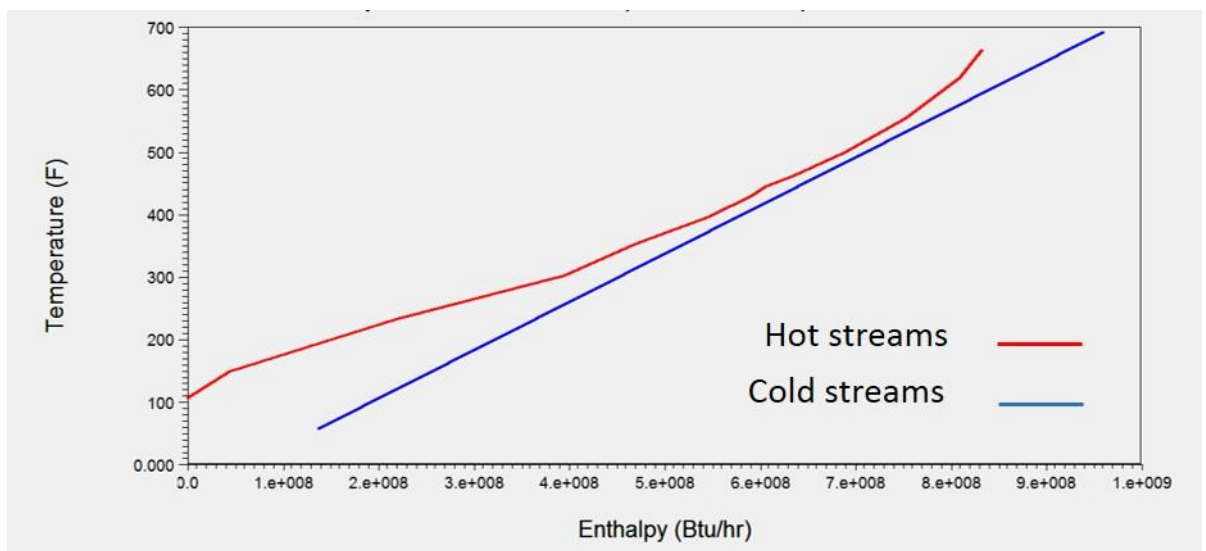


Figure (31)
Composite Curves of Second Alternative (Reboilers)

The results from energy analyses have shown that the heating and cooling duties of stripping steam alternative are 197 MMBTU/hr and 152.6 MMBTU/hr respectively while in the case of reboilers are 187 BTU/hr and 139.1 MMBTU/hr. As shown in Table 16 that second alternative (reboilers) required lower energy by around 10MMBTU/hr. In addition, the cooling duty for the same alternative is lower which means lower consumption of cooling water.

Table (16)
Heating and Cooling Duties of Both Alternatives

		Heating Duties (MMBTU/hr)	Cooling Duties (MMBTU/hr)
1st Alternative (stripping steam)	Process Streams	151.9	152.6
	Utilities	45.1	
	Total	197.0	
2nd Alternative (reboilers)	Process Streams	125.7	139.1
	Utilities	61.9	
	Total	187.6	

According to previous analyses the amount of fuel gas that is going to be needed for fired furnace can be calculated by dividing the required heating duty by the heating value of one unit volume. Furthermore, emissions can be estimated by multiplying the amount of needed fuel gas by emission factor for each type of pollutants as shown in Table 17.

Table (17)
Calculation of Required Fuel Gas, Cooling Water and Estimated Emissions.

	1st alternative (stripping steam)	2nd alternative (reboilers)
Heating duties (MMBTU/DAY)	4729.55	4502.14
Natural gas heating value (BTU/SCF)	860	
Total fuel gas required 80 % efficiency (MSCF/DAY)	6874.35	6543.81
CO ₂ emission factor (Ton/MSCF)	0.04629	
CO ₂ emission rate (Ton/Day)	318.21	302.91
SO _x emission factor (Ton/MSCF)	0.003575	
SO _x emission rate (Ton/Day)	24.58	23.39
NO _x emission factor (Ton/MSCF)	0.007966	
NO _x emission rate (Ton/Day)	54.76	52.13
Consumption of cooling water (Mbbl/hr)	1012.90	923.30
The following assumption have been made to simplify the calculations:		
• Natural gas (khuf gas) is used for fire heater. • Complete combustion in heaters. • Emission factors calculated based on gas composition data for (khuf gas) • NO_x form atmospheric nitrogen was not estimated because it is highly dependent on burning temperature and burners designed.		

Calculations indicate that second alternative will require lower energy than the first alternative by 4.8% and will produce lower amount of emissions by the same percent. Moreover, second alternative will require lower amount of cooling water by 8.8%.

4.3.2 Discussion

The aim of the case study was to illustrate how PI can facilitate the selection of alternatives within EIA process. Due to its energy intensity and the potential of heat recovery by applying PI, atmospheric distillation unit was chosen to be the topic of the case study. The design of Chang et al.

(2012) was used as base case then an alternative design was proposed. The major difference between both alternatives was the vaporizing approach of light ends on side strippers where first alternative used the direct injection of stripping steam while the other alternative used reboilers.

Simulation results showed that if a reboiler completely replaces the stripping steam, in the side strippers the draw-off temperatures would be increased, that indicate higher potential for heat exchange.

Performed energy analyses indicate that second alternative has higher potential for heat exchange by 3.2%. Moreover, the production of foul water has been decreased by 37% in the reboilers case. Possible emissions quantities were estimated. It was noted that second alternative has the potential to produce lower amount of emissions (CO_2 , SO_x , and NO_x) by 4.8 % than the base case design.

It can be concluded that, using reboilers, rather than injection of steam stripping can improve the efficiency of the process. Installation of reboilers will decrease the heating and cooling requirements of the process, and increase heat recovery opportunities.

Bahrain as well as GCC countries are among the highest consumers of energy and producers of CO_2 per capita (Reiche, 2010). Bahrain has the potential to carry out energy conservation strategies and a carbon emissions reduction policy in the long run without impeding economic growth (Jafari et al., 2015). One of the taken actions was a cooperation work between Bapco, the Gulf Petrochemicals Industries Company (GPIC), and Bahrain national gas company (Banagas) on ways to reduce CO_2 emissions within Bahrain oil's sector (Abdmouleh et al., 2015). Provided case study has illustrated how PI can be one of the measures to achieve this goal.

4.4 Overall Discussion and Recommendations

The present study was based on three main pillars as illustrated in Figure 32. First pillar aimed to present the current practice of EIA process in parallel with project life cycle for oil and gas sector in Bahrain. Second, evaluation of the role of EIA practice in Bahrain toward energy conservation and emission reduction. Third, a case study to illustrate how PI can facilitate the selection of alternatives for EIA process within oil and gas sector.

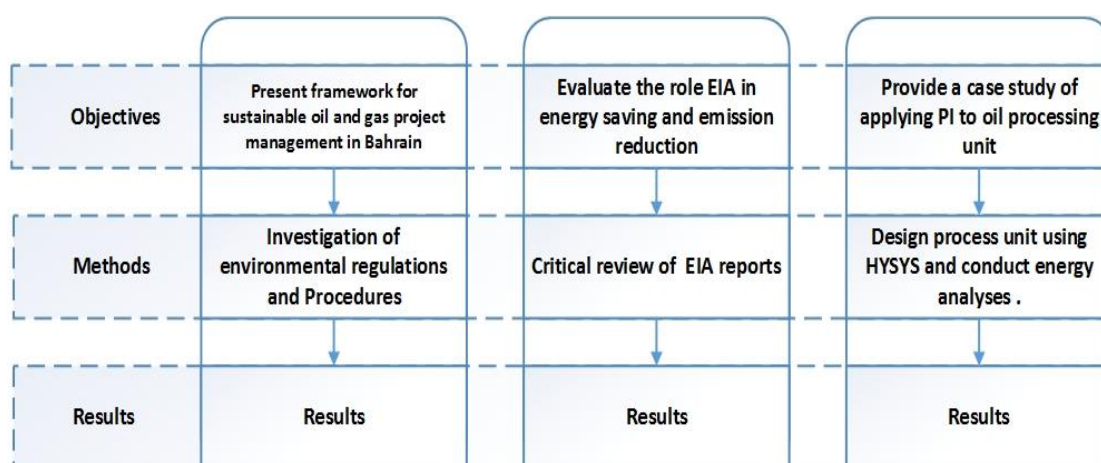


Figure (32)
Pillars of the Research

Figure 33 demonstrate how the three pillars of the study are connected together. The overall theme of the present study was the environmental impact of energy use within industrial sector. The current practice in Bahrain concerning EIA process and projects life cycle has been visualized for the oil and gas sector in a framework. The framework has shown that environmental aspects are considered throughout the life cycle of oil and gas projects, which reflect environmentally sound practice.

The study first tried to find an answer the question: What is the role of EIA practice in Bahrain toward energy conservation and emission

reduction?. To answer this question, selected EIA reports have been evaluated. Evaluation revealed an urgent need for the following; enforcing legislations to ensure efficient use of energy within industrial sector, adopting SEA practice in Bahrain and link it to energy planning, and encouraging industrial companies to adopt energy management system. Therefore, it recommends the inclusion of such system within the framework of sustainable project life cycle for oil and gas sector in Bahrain in order to play the role of follow up to EIA mitigation measures. Figure 34 represent the inclusion of energy management system to the previously illustrated framework.

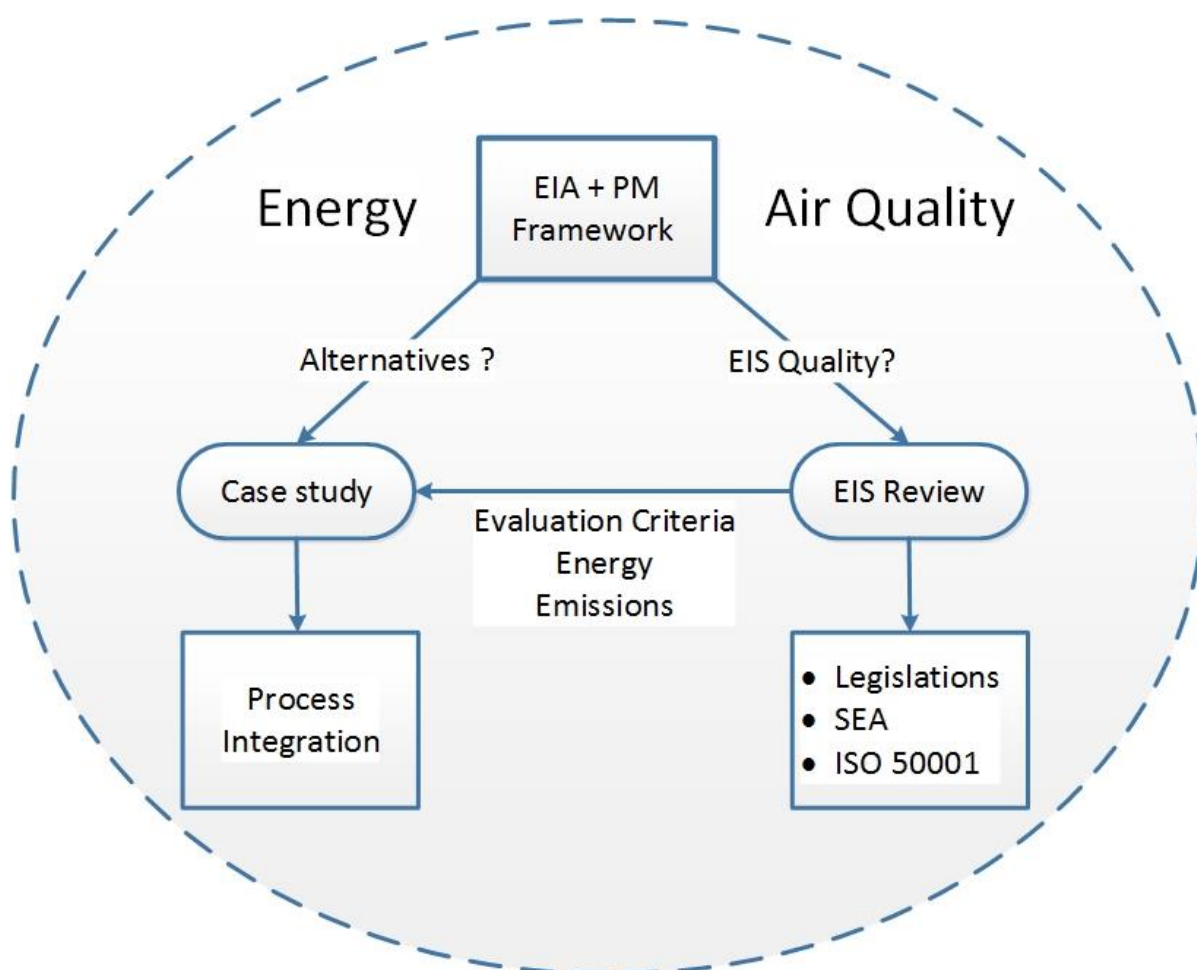


Figure (33)
Overall Discussion Summary

The framework showed a potential to enhance the practice of generation and selecting alternatives based on environmental and energy criteria. The performed case study has shown how PI can be applied to generate and differentiate between alternatives and aid industrial sector in promoting efficient use of energy and reduction of emissions.

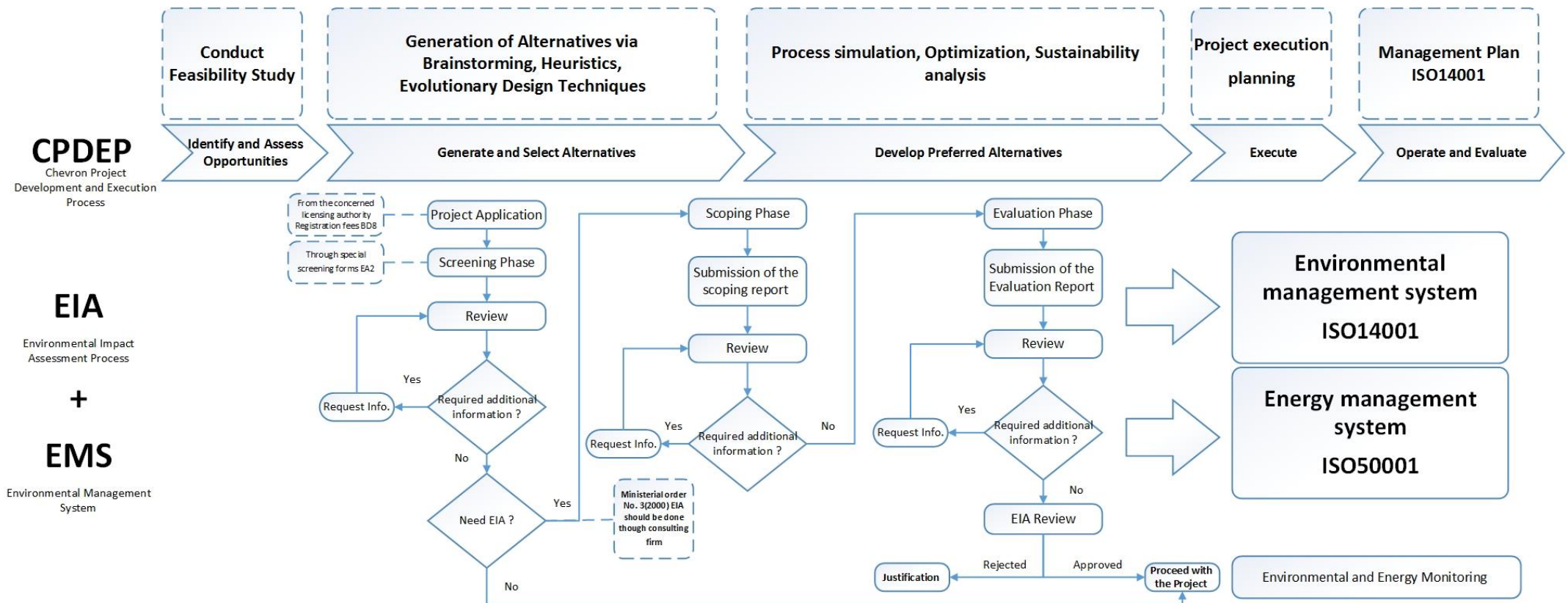


Figure (34)
Suggested Framework of Environmental Tools and Project Cycle of Oil and Gas Sector in Bahrain

The topic of the present study is a viable area of research and can be enhanced by conducting relevant researches such as:

- Forming similar frameworks for other industrial sectors or development activities, to ensure proper alignment between project life cycle and EIA process.
- Perform environmental evaluation to other aspects of EIA reports; sound pollution, water pollution, health and wellbeing of neighboring public, and public participation within EIA process.
- Evaluate the current practices of energy management within industrial premises in Bahrain.
- Conduct other case studies of existing industries to compare between possible alternatives to promote efficient use of energy.

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